19.

Materials for the Study of the Life History of *Tarpon atlanticus*.

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(Text-figures 1-9.)

Introduction.

Although the tarpon, *Tarpon atlanticus* (Cuvier and Valenciennes) is a well known sportsman's fish and is sought for sporting purposes throughout most of its range, aside from a considerable sportsman's lore there is surprisingly little known about its life history and habits, in spite of the fact that most of its life is spent in thoroughly accessible places.

An attempt to obtain scientific data on the life history and behavior of the species was initiated in 1938 under the encouragement of the late Mrs. Gracia Rhinehart. For this purpose she gave financial support and provided a location in the heart of tarpon country. To this end a field laboratory was established on Palmetto Key, in Pine Island Sound on the West Coast of Florida, under the aegis of the New York Aquarium. The cooperation of the Peabody Museum of Natural History, made possible through the good will of the Director at that time, Professor A. E. Parr, and the Zoologist, Dr. Stanley Ball, has been invaluable to the work. It took the form, to a large extent, of lending the Museum Collector, Mr. Marshall B. Bishop, for long periods of time. His indefatigable services have been of the greatest value. Among other things, practically the entire burden of the tagging operations devolved on him. The United States Bureau of Fisheries (now part of the Fish and Wildlife Service), through the good offices of Dr. Elmer Higgins and Mr. Robert Nesbit, enabled us to use government tags for the tagging operations, a feature we found of much value. Later Mr. Nesbit was kind enough to undertake to make celluloid imprints of certain of the tarpon scale samples, a matter which greatly facilitated the study of the markings on them. He employed a new method suitable for these large scales which was devised by him and without which we would have been considerably handicapped. Scales of the smaller fish were mounted for study by Mr. Paul Benzer of the National Youth Administration at the laboratories of the old New York Aquarium. When the laboratory work was about one-half finished, operations were transferred to the American Museum of Natural History where most of the remainder of the work was carried out in the laboratories of the Department of Animal Behavior, through the courtesy of Dr. Frank A. Beach. The manuscript was finished in the Department of Ichthyology.

The field laboratory and its location, about four miles south of Boca Grande Pass and three north of Captiva Pass, was found ideal for the purposes. Both of these places are used to a great extent for tarpon angling. Notwithstanding these advantages, the accumulation of pertinent data was not easy and there is still much to be done, now largely forcibly suspended by the restrictions imposed by war. For this reason, as well as others, it was thought best to make available the data and their analysis so far as we have been able to carry it.

A considerable number of students not already mentioned assisted with many of the items under study. They include the following list, to whom we are grateful: Mr. L. L. Babcock, author of "The Tarpon;" Dr. Richard Cox, New York University; Mr. B. Dontzin, Cornell University; Mr. L. A. Krumholz, University of Michigan; and Mr. Stewart Springer, Shark Industries, Homestead, Florida.

To this list should be added many anglers, local fishermen and others to whom thanks are due, for one item or another. Especial mention must be made of Mrs. Mary Roberts Rinehart and Mrs. J. Coggeshal, and all the active commercial fishermen of the Spearing family.

As this study progressed many other items of ichthyological interest appeared incidentally. Those pertinent to the study of the tarpon itself which have been published follow: Breder (1939a, b and c, 1940a, 1942e), Shlaifer (1941), Shlaifer and Breder (1940). Publications on other subjects directly derived from the work of this field station are as follows: Bishop

(1940), Breder (1939d, 1940b and c, 1941a, b and c, 1942a, b, c and d, 1943 and 1944 Breder and Springer (1940), Breder and Krumholz (1941 and 1943), Cox and Breder (1943), Gregory and Conrad (1943), Merriman (1940), Storey (1940). Numerous other items are in press or still under study.

Activity at the field station covered various periods, as needs demanded and the press of other matters permitted. From 1938 up to and including 1942, parts of each year were spent in field work. Most of this occupied the spring and summer months so as to cover the tarpon spawning season.

The Habitat of Tarpon.

Tarpon are known mostly in their larger sizes. In lengths mostly upward of three feet they are generally to be found in coastwise waters not far from shore and most frequently in inlets, estuaries and passes between islands. Sometimes they may be found well up rivers and frequently they enter fresh waters for considerable distances. They are not normally found in the open ocean at any great distance from shore.

Fish under two feet in length are only rarely taken in such places as described above and those of considerably smaller sizes are known almost entirely from small bodies of water, and most frequently are land-locked when found. Such places may be a considerable distance from the seaside. Otherwise the smaller sized fish are generally found well up rivers. In the vicinity of the place where this work was carried out, the Peace River and the Shark River are favored haunts of the species in its smaller sizes, although large fishes are often taken, especially in the lower reaches of the latter. Specimens may range down to sizes of a little over two inches in length. Below that their whereabouts is still a mystery and this item is discussed under a consideration of the larval tarpon. The finding of small tarpon has frequently been the subject of notices by the finder. Such are discussed by Evermann and Marsh (1902), Coker (1921a and b), Eigenmann (1921), Beebe (1927 and 1928), Beebe and Tee-Van (1928), Storey and Perry (1933) and Breder (1933, 1937, 1939b and c). All but one of these refer to the occurrences in land-locked or practically land-locked places. These they evidently enter from a previous existence in the sea, as indicated by Babcock (1936) and Breder (1939c), at times of temporary connections with open water. In one case Mr. Bishop actually saw them entering a newly storm-made cut which was again closed in a short time, securely land-locking these fishes. Of this case Breder (1939c) wrote:

"It has long been suspected that small tarpon may get into the odd places in which they are sometimes found by being driven in on the wings of a hurricane or late summer storm. Mr. Bishop was exceptionally fortunate in being in the field when two earlier-than-usual blows piled up the water into arms and other places that are seldom invaded by high water. Wherever there was such a connection with the sea Mr. Bishop plied his nets to see if the new ocean water brought anything in with it. Since he well knew from last season's work just what was in these places, he was in an excellent position to obtain a proper understanding of what was going on—if anything. Last year there were no such early storms and the places were either completely dry, or stagnant to such an extent that the only local species capable of survival was the air-breathing tarpon.

"Place after place was visited and nothing but the usual run of small shore fishes could be found in these freshly inundated pools. Mr. Bishop was about to give up and almost ready to invoke the old and feeble dodge of attributing the presence of fishes in odd places to wading birds carrying eggs adherent to their feet—only tarpon eggs are not sticky—when he came upon the last accessible place he knew about. This is on the south shore of Sanibel Island, near Point Ybel. Here, on overflowed land destined to become dry again shortly, he found his quest—tiny tarpon just as they entered these sequestered lagoons. The first time he saw this place it was still connected with the sea, but later was cut off and rapidly evaporating. These particular little tarpon were doomed to desiccation—or as Bishop puts it, before that, to be cleaned up by the abundant bird life when the water subsides a few inches, and before real desiccation commences. This would appear to be the frequent fate of many little tarpon every time they attempt to venture inland."

Such land-locked places vary considerably, some being actually more saline than the ocean, due to evaporation, while others may be practically fresh water. Frequently these pools are exceedingly foul and filled with decomposing organic matter and are of such a nature that other fishes cannot endure. Tarpon by virtue of their ability to breathe atmospheric oxygen survive easily in such places. The significance of these peculiarities of habitat plays an important part in an attempt to understand the nature of the growth of these fishes as will develop in the discussion of the interpretation of the markings on the scales. The anatomy of the lung-like swim blader is discussed by Hildebrand in Babcock (1936) and its importance in respiration by Shlaifer and Breder (1940), Shlaifer (1941) and Breder (1942e).

The occurrence of large tarpon in fresh water has been frequently noted. Such places as Lake Nicaragua, Simmons (1900), Gill (1907), and Miller (1936); the Chagres River, Panama, Meek and Hildebrand (1923), Breder (1925), Hildebrand (1937 and 1939), and Babcock (1936), are both famous for tarpon. Babcock gives an extended list of such places covering, in addition to the United States, Central America and the West Indies. He mentions reports of tarpon being found more than one hundred miles inland and the author has seen tarpon in the Rio Tampaon, near Pujal, S.L.P., Mexico, at a point which is considerably more than 100 miles from the sea as the river winds, while Dr. Myron Gordon reports having seen them in the Rio Tonto not distant from the town of Papaloapan, in the State of Oaxaca, Mexico, some eighty miles from the sea measured along the river. The ability of tarpon to live in fresh water is considerable, if not indefinite, and there are still living in a small fresh-water aquarium at the Bingham Oceanographic Laboratory, Yale University, several small specimens taken in 1938, with no indication of deterioration due to the nature of the water, during this period of six years.

Body Proportions of Tarpon.

In order to be prepared to make as much use as possible of anglers' data, it became necessary to determine correlations between the various measures that have been used to measure tarpon. No single method is completely satisfactory, but the customary "standard length" is least objectionable for most ichthyological purposes. A series of specimens have been measured according to the several measurements in use by tarpon anglers. This material has been reduced to percentage of the standard length and is given in Table I. The various measurements as here understood may be defined as follows.

Standard length. The distance in a straight line from the tip of the snout to the caudal base.

Total length. Similar to the standard length but measured to the tip of the caudal fin in a "normal" expanded position.

Overall length. Similar to the standard length but measured to the tip of the caudal fin with the lobes pressed together.

Length to fork. Similar to standard length but measured to the tip of the shortest central caudal ray.

Length including jaw. Similar to overall length but measured from the tip of the lower jaw when the mouth is closed.

Aside from faulty tapes and poor techniques, there is considerable difficulty in obtaining accurate measurements of tarpon in the larger sizes. One of the sources of difficulty is the changes in length induced by stretching the fish as it is dragged about, generally by the lower jaw.

There is evidently only a slight amount of heterogony in the growth of these fishes but the somewhat changing relationships of the various measures of length is broken down in Table I into a series of size groups with which material may be compared. More of such measurements must be obtained, especially in the larger sizes, before a nomographic or other similar treatment would be warranted. Nevertheless this table can yield estimates from any one of the measurements that are of sufficient accuracy to give reasonably satisfactory estimates.

These figures have been based on wild fish exclusively, for it has been found that specimens kept in aquaria for long periods showed a tendency for the tail to grow proportionally longer. This condition is possibly related to lack of vigorous swimming enforced on such specimens. Due to the fish's efforts to swim through the glass, sometimes continual, an effort carried on longer in this species than in any other known to the author, there frequently results a deformation of the jaw, which, while not apparently inconveniencing the fish, further modifies the relations of its longitudinal proportions.

The weight-length relationships of tarpon need many more data to be worked out in a thoroughly satisfactory manner. Normally tarpon are slab-sided fish, relatively light in weight for their length, but during the spawning season the females may increase considerably in weight. Although anglers like to weigh their fish, it is probably the least satisfactory measure for any analytical study and little, of use in present connections, can be done with catch records that give weight only. This is further complicated by the fact that in the warm climates in which the tarpon is found, the weight of the fish changes considerably after lying around in boats or on docks for variable periods, sometimes wet and sometimes dry. Babcock (1936) discusses this at length. He gives a formula showing the relationship of length and weight, in which the girth of the fish is taken into account. At this writing we are unable to improve on the accuracy of this purely empirical expression and probably it is adequate to the present uncertain nature of the variations that come into any measurement made on large tarpon. The formula which Babcock (1936) gives may be expressed as follows.

TABLE I. COMPARISON OF MEASURES OF LENGTH IN TARPON ACCORDING TO SIZE GROUPS.
Number of specimens precedes each measurement in parenthesis.
Dimensions expressed as per cent. of standard lengths.

Range	STANDARD LENGTHS IN CM.	Min.	Mean	Max.	TOTAL LENGTHS	Min.	Mean	Max.	OVERALL LENGTHS	Min.	Mean	Max.	LENGTHS TO FORK	Min.	Mean	Max.	LENGTHS INC. JAW	Min.	Mean	Max.
5–6	(47)	5.0	5.4	5.9	(13)	129.3	131.5	134.0	(5)	133.0	134.9	136.0	(30)	110.5	112.4	114.5	(4)	135.0	136.6	138.0
6–7	(7)	6.0	6.2	6.7	(2)	128.2	128.4	128.7	—	—	—	—	(5)	111.6	112.2	113.2	—	—	—	—
7–8	(17)	7.0	7.6	7.9	(1)	—	127.4	—	(1)	—	140.1	—	(10)	110.2	111.7	133.0	(1)	—	133.0	—
8–9	(26)	8.0	8.5	8.9	(10)	126.9	129.0	130.1	(10)	128.1	130.5	132.0	(20)	110.0	111.8	119.2	(10)	130.0	131.7	134.0
9–10	(26)	9.0	9.4	9.8	(16)	122.3	128.2	131.2	(16)	123.4	125.6	131.9	(23)	109.1	111.6	122.8	(16)	124.4	131.1	139.9
10–11	(9)	10.0	10.5	10.9	(4)	126.1	127.0	129.0	(4)	127.1	128.3	130.5	(4)	109.9	110.0	110.7	(4)	128.0	129.4	131.0
11–12	(7)	11.0	11.4	11.9	(2)	129.3	130.1	130.9	(2)	130.2	130.7	131.2	(4)	109.1	109.0	111.2	(2)	131.5	132.1	132.7
12–13	(5)	12.1	12.4	12.9	(2)	126.0	127.4	128.8	(2)	126.4	128.3	130.3	(3)	107.7	109.4	112.4	(2)	127.8	130.2	132.6
13–14	(3)	13.7	13.8	13.9	(2)	124.4	125.4	126.5	(2)	125.1	126.5	127.9	(3)	107.9	109.1	110.1	(2)	127.2	128.1	129.0
14–15	(2)	14.2	14.3	14.4	—	—	—	—	—	—	—	—	(1)	—	108.0	—	—	—	—	—
15–16	(2)	15.0	15.2	15.3	—	—	—	—	—	—	—	—	(2)	108.4	108.8	109.2	—	—	—	—
17–18	(2)	17.0	17.0	17.1	—	—	—	—	—	—	—	—	(2)	106.9	107.9	109.0	—	—	—	—
58–59	(1)	—	58.4	—	(1)	—	122.7	—	—	—	—	—	—	—	—	—	—	—	—	—
61–62	(2)	61.0	61.3	61.6	(1)	—	119.4	—	—	—	—	—	(1)	—	104.2	—	—	—	—	—
118–119	(1)	—	118.1	—	(1)	—	117.0	—	—	—	—	—	—	—	—	—	—	—	—	—
123–124	(1)	—	123.1	—	(1)	—	113.5	—	—	—	—	—	—	—	—	—	—	—	—	—
125–126	(1)	—	125.8	—	(1)	—	113.2	—	—	—	—	—	—	—	—	—	—	—	—	—
141–142	(1)	—	141.0	—	(1)	—	117.0	—	—	—	—	—	—	—	—	—	—	—	—	—
146–147	(1)	—	146.8	—	(1)	—	120.8	—	(1)	—	124.8	—	—	—	—	—	—	—	—	—
149–150	(1)	—	149.8	—	(1)	—	118.0	—	—	—	—	—	—	—	—	—	—	—	—	—
188–189	(1)	—	189.0	—	(1)	—	116.0	—	(1)	—	119.8	—	—	—	—	—	—	—	—	—
193–194	(2)	193.0	193.9	194.9	(2)	114.1	116.2	118.3	(2)	121.9	120.5	119.2	—	—	—	—	—	—	—	—
202–203	(1)	—	202.8	—	(1)	—	114.5	—	(1)	—	120.9	—	—	—	—	—	—	—	—	—
	(164)				(59)				(47)				(110)				(41)			

$$W = \frac{G^2 \times L}{800}$$

In which: G = girth in inches, L = tota length in inches, W = weight in pound

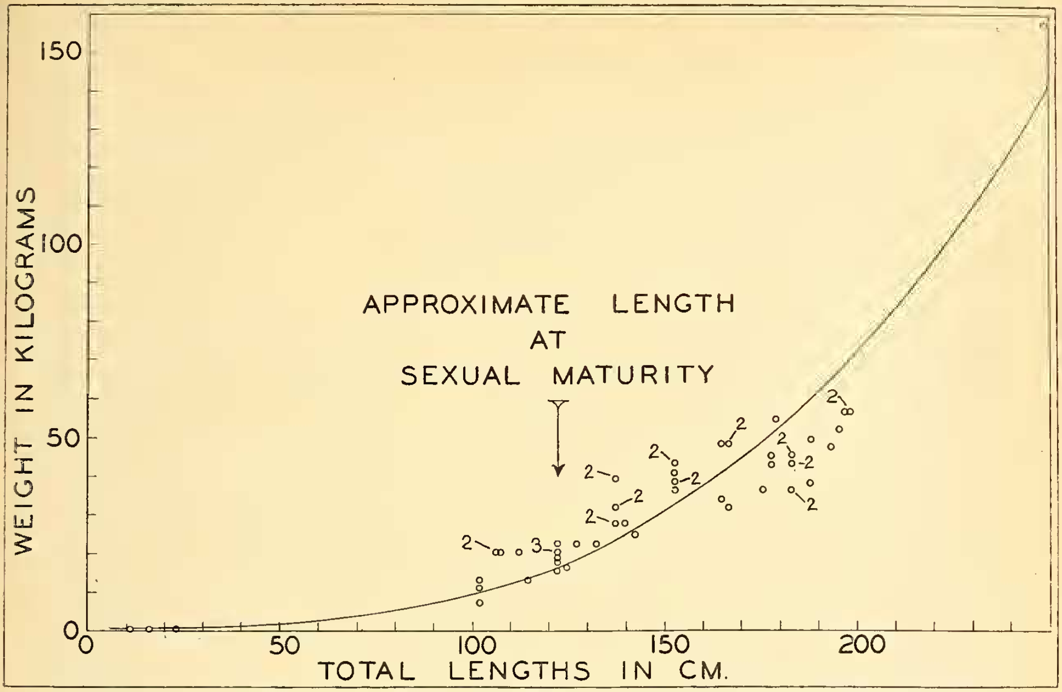
Measurements of length and weight of number of specimens caught by Mr. Bisho are given in Table II, together with som other data culled from the literature an converted to the same standards. These dat indicate a considerable variation in weigh for a given size, which feature shows clearl in the graphic presentation of Text-figur 1 and emphasizes the utility of the girt factor in the formula of Babcock. Unfor tunately many measurements of others wer necessarily discarded because of obviou difficulties in interpreting the nature of th "length" measurement.

The exponential length-weight ratio i fishes has been discussed by Hecht (1916 Hile (1931), Shapiro (1943) and other The derivation of a formula expressing thi ratio within reasonable limits of size ma be found in any of the above. While it i generally applicable to fishes, it naturall gives a much closer approximation in thos

TABLE II. LENGTH AND WEIGHT OF TARPON.
Measurements taken by M. B. Bishop unless otherwise indicated.

TOTAL LENGTHS IN CM.	WEIGHT IN KG.	TOTAL LENGTHS IN CM.	WEIGHT IN KG.
10.0	0.0050 [2]	139.9	27.215
10.8	0.0105 [1]	142.2	24.947
16.3	0.0125 [1]	152.5	36.287
23.2	0.0650 [2]	152.5	38.555
76.3	18.143	152.5	43.091
101.5	11.339	152.5	40.823
101.5	13.607	152.5	43.091
101.5	7.711	152.5	38.555
106.6	20.411	165.0	40.832
106.6	20.411	165.0	34.019
107.0	20.411	167.5	40.823
111.8	11.339	167.5	31.751
114.1	13.607	167.5	40.823
122.0	15.875	175.5	36.287
122.0	22.679	178.0	45.359
122.0	20.411	178.0	43.091
122.0	18.143	179.0	54.430
122.0	20.411	183.0	43.091
122.0	15.875	183.0	43.091
122.0	19.050	183.0	54.430
122.0	20.411	183.0	36.287
124.5	16.329 [3]	183.0	36.287
127.0	22.679	183.0	45.359
132.0	22.679	188.0	49.849
137.0	31.751	188.0	38.500
137.0	31.751	193.0	47.626
137.0	27.215	195.5	52.162
137.0	27.215	197.0	56.698
137.0	29.483	197.0	56.698
137.0	39.462	198.0	56.698
		249.0	158.756

[1] From Storey and Perry (1933).
[2] From Beebe and Tee-Van (1928).
[3] From Babcock (1936).
[4] From Breder (1925).



TEXT-FIG. 1. Length and weight relationships of tarpon. Based on data of Table II. Solid line represents best fit of the exponential relationship of length and weight. See text for full explanation for formula $W = \frac{0.9\ L^3}{100{,}000}$.

which show only slight heterogonic growth characteristics, than in those displaying large proportional changes with increasing size. Since the tarpon is conspicuously one of the former, as is indicated by the measurements of Table III, it should be expected to subscribe to such a formula in a reasonably satisfactory manner.

The basic formula states that the weight varies directly as the cube of the length, as follows:

$$\frac{W}{L^3} = c \quad \text{or} \quad W = cL^3$$

where W = weight, L = length and c = an empirical constant derived from the above formula and differing for each species dependent on its characteristic slimness or rotundity. When the measurements are expressed in the metric system, it is convenient to introduce another constant, k, where if, as in the present case, the measurements have been made in centimeters and kilograms:

$$\frac{k}{100{,}000} = c$$

This then yields the equation:

$$W = \frac{kL^3}{100{,}000}$$

Since it has been found by purely empirical means that for tarpon the value of k giving the closest fit to the data at hand is 0.9, the working expressions become:

$$W = \frac{0.9\ L^3}{100{,}000} \quad \text{and} \quad L = \sqrt[3]{\frac{100{,}000\ W}{0.9}}$$

when weight is expressed in kilograms and length in centimeters.

This equation may be most conveniently transformed for use with inches and pounds in the following manner: L is multiplied by 2.54, the number of cms. in an inch, and W is multiplied by 0.45359, the number of kilos. in a pound. The expressions then become as follows:

$$0.45359\ W = \frac{0.9(2.54L)^3}{100{,}000} \quad \text{or}$$

$$W = \frac{(2.54L)^3}{50{,}400} \quad \text{and} \quad L = \frac{\sqrt[3]{50{,}400\ W}}{2.54}$$

These, of course, could be transformed in other ways but the above is perhaps as convenient as any.

Some of the deviations from the mean in the present data are fairly large, as indicated in Text-figure 1, but probably have more to do with individual variation, associated with the sex and the fatness of

TABLE III—CHANGE OF PROPORTIONS IN RELATION TO SIZE IN TARPON.

Number of specimens precedes each measurement in parenthesis.
Dimensions expressed as per cent of standard lengths.

STANDARD LENGTHS IN CM.					HEAD				DEPTH				SNOUT				ORBIT			
Range		Min.	Mean	Max.		Min.	Mean	Max.		Min.	Mean	Max.		Min.	Mean	Max.		Min.	Mean	Max.
5–6	(47)	5.0	5.4	5.9	(34)	30.0	31.3	33.0	(38)	23.1	25.0	26.9	(37)	5.8	6.9	9.3	(38)	6.5	7.6	9.3
6–7	(7)	6.0	6.2	6.7	(7)	30.2	30.9	32.0	(6)	24.3	25.3	26.3	(7)	6.4	7.1	9.2	(7)	6.9	7.5	9.2
7–8	(17)	7.0	7.6	7.9	(16)	28.9	30.4	32.9	(15)	20.9	23.3	25.4	(17)	5.7	6.7	7.5	(17)	6.7	7.6	8.6
8–9	(26)	8.0	8.5	8.9	(25)	27.9	30.0	32.6	(12)	23.6	25.1	26.6	(24)	5.6	6.4	6.7	(26)	6.1	7.7	8.9
9–10	(26)	9.0	9.4	9.8	(26)	27.2	29.3	30.6	(25)	22.2	24.4	26.2	(25)	5.4	6.0	6.5	(26)	6.2	7.7	8.7
10–11	(9)	10.0	10.5	10.9	(9)	27.3	28.4	29.3	(9)	20.9	25.1	26.4	(9)	5.2	6.0	6.5	(9)	6.1	7.0	8.3
11–12	(7)	11.0	11.4	11.9	(7)	26.8	28.5	29.8	(7)	21.8	24.4	27.0	(7)	5.8	6.0	6.5	(7)	5.8	7.2	7.7
12–13	(5)	12.1	12.4	12.9	(5)	25.6	27.6	28.9	(5)	22.6	24.0	25.4	(5)	5.4	5.9	6.5	(5)	6.3	6.8	7.7
13–14	(3)	13.7	13.8	13.9	(3)	24.1	26.2	27.7	(3)	24.9	25.5	25.9	(3)	5.5	5.9	6.2	(3)	6.6	6.8	7.2
14–15	(2)	14.2	14.3	14.4	(2)	26.2	26.5	26.8	(2)	22.2	23.1	24.0	(2)	5.5	5.7	5.8	(2)	6.3	6.4	6.6
15–16	(2)	15.0	15.2	15.3	(2)	27.0	27.1	27.2	(2)	24.1	24.2	24.2	(2)	5.2	5.6	6.0	(2)	6.8	6.8	6.8
17–18	(2)	17.0	17.0	17.1	(2)	26.8	26.8	26.8	(2)	21.8	23.1	24.4	(2)	5.6	5.6	5.6	(2)	6.0	6.4	6.8
58–59	(1)	—	58.4	—	(1)	—	21.8	—	—	—	—	—	(1)	—	4.6	—	(1)	—	4.4	—
61–62	(2)	61.0	61.3	61.6	(2)	22.1	22.5	23.0	—	—	—	—	(2)	4.3	4.5	4.6	(2)	4.3	5.2	6.1
146–147	(1)	—	146.8	—	(1)	—	22.8	—	—	—	—	—	—	—	—	—	(1)	—	4.0	—
188–189	(1)	—	189.0	—	(1)	—	24.5	—	—	—	—	—	—	—	—	—	(1)	—	3.6	—
193–194	(2)	193.0	193.5	194.9	(2)	21.5	22.0	22.4	—	—	—	—	—	—	—	—	(2)	3.5	3.5	3.6
202–203	(1)	—	202.8	—	(1)	—	23.3	—	—	—	—	—	—	—	—	—	(1)	—	3.6	—
	(164)				(146)				(126)				(143)				(152)			

STANDARD LENGTHS IN CM.					MAXILLARY				INTERORBITAL				DORSAL ORIGIN				ANAL ORIGIN			
Range		Min.	Mean	Max.		Min.	Mean	Max.		Min.	Mean	Max.		Min.	Mean	Max.		Min.	Mean	Max.
5–6	(47)	5.0	5.4	5.9	(36)	17.1	18.6	20.2	(40)	3.6	5.5	6.3	(38)	50.6	54.0	50.8	(37)	67.2	70.9	73.2
6–7	(7)	6.0	6.2	6.7	(7)	17.9	18.5	20.0	(7)	4.7	5.3	5.7	(6)	51.5	52.8	55.3	(7)	69.7	71.2	73.5
7–8	(17)	7.0	7.6	7.9	(16)	17.3	18.3	19.5	(17)	4.8	5.4	5.7	(16)	52.5	54.7	56.7	(16)	68.0	70.7	72.5
8–9	(26)	8.0	8.5	8.9	(24)	16.8	18.2	19.4	(24)	4.9	5.5	6.4	(25)	51.3	53.5	56.6	(25)	66.5	70.5	73.6
9–10	(26)	9.0	9.4	9.8	(26)	16.4	17.6	18.5	(25)	4.8	5.4	5.8	(25)	52.4	53.7	56.2	(25)	67.8	70.0	79.8
10–11	(9)	10.0	10.5	10.9	(9)	16.7	17.4	17.8	(9)	4.9	5.3	6.0	(9)	51.0	53.7	55.8	(9)	67.4	69.0	71.5
11–12	(7)	11.0	11.4	11.9	(7)	16.0	17.5	17.7	(7)	5.2	5.5	5.9	(7)	51.2	53.1	54.8	(7)	68.2	69.9	72.0
12–13	(5)	12.1	12.4	12.9	(5)	16.3	17.0	17.8	(5)	4.9	5.6	5.7	(5)	50.8	53.0	54.3	(5)	67.5	69.7	73.0
13–14	(3)	13.7	13.8	13.9	(3)	15.3	16.2	17.2	(3)	5.1	5.5	6.2	(3)	51.8	53.3	55.5	(3)	68.2	69.3	70.6
14–15	(2)	14.2	14.3	14.4	(2)	16.1	16.2	16.3	(1)	—	4.8	—	(2)	53.9	54.5	54.5	(2)	67.8	69.2	70.5
15–16	(2)	15.0	15.2	15.3	(2)	16.0	16.1	16.1	(2)	4.7	5.2	5.7	(2)	54.8	54.9	55.0	(2)	69.4	69.4	69.4
17–18	(2)	17.0	17.0	17.1	(2)	16.4	16.7	17.0	(2)	5.2	5.4	5.5	(2)	53.0	53.1	53.4	(2)	72.0	71.5	71.0
58–59	(1)	—	58.4	—	(1)	—	13.2	—	—	—	—	—	(1)	—	56.4	—	(1)	—	68.4	—
61–62	(2)	61.0	61.3	61.6	(2)	12.6	12.9	13.1	(2)	4.6	4.6	4.6	(2)	54.2	54.9	55.6	(2)	66.0	68.4	70.7
146–147	(1)	—	146.8	—	(1)	—	13.4	—	—	—	—	—	(1)	—	51.6	—	(1)	—	68.4	—
188–189	(1)	—	189.0	—	(1)	—	13.5	—	—	—	—	—	—	—	—	—	—	—	—	—
193–194	(2)	193.0	193.5	194.9	(2)	12.7	12.8	12.9	—	—	—	—	—	—	—	—	—	—	—	—
202–203	(1)	—	202.8	—	(1)	—	12.4	—	—	—	—	—	—	—	—	—	—	—	—	—
	(164)				(147)				(144)				(144)				(144)			

TABLE III (CONTINUED)—CHANGE OF PROPORTIONS IN RELATION TO SIZE IN TARPON.

Number of specimens precedes each measurement in parenthesis.
Dimensions expressed as per cent of standard lengths.

STANDARD LENGTHS IN CM.					PECTORAL INSERTION				VENTRAL INSERTION				DORSAL BASE				ANAL BASE			
Range		Min.	Mean	Max.		Min.	Mean	Max.		Min.	Mean	Max.		Min.	Mean	Max.		Min.	Mean	Max.
5–6	(47)	5.0	5.4	5.9	(38)	28.6	30.9	33.6	(38)	49.2	52.2	54.2	(38)	8.7	10.2	11.9	(38)	17.1	20.2	21.8
6–7	(7)	6.0	6.2	6.7	(7)	29.4	31.2	32.6	(7)	50.5	51.9	53.2	(7)	9.1	10.2	11.2	(7)	19.0	20.0	21.3
7–8	(17)	7.0	7.6	7.9	(16)	27.8	29.9	34.1	(16)	46.2	50.1	52.2	(15)	8.2	9.4	10.4	(17)	18.5	19.8	22.5
8–9	(26)	8.0	8.5	8.9	(24)	26.8	29.9	33.2	(24)	43.7	50.1	52.6	(24)	8.5	9.7	11.1	(24)	18.1	20.0	21.9
9–10	(26)	9.0	9.4	9.8	(25)	27.5	29.0	34.6	(26)	46.8	48.7	52.0	(25)	8.4	9.2	11.3	(25)	18.6	20.1	22.2
10–11	(9)	10.0	10.5	10.9	(9)	27.1	28.1	29.7	(9)	46.3	48.2	50.5	(8)	8.4	9.3	10.1	(9)	19.4	20.1	20.8
11–12	(7)	11.0	11.4	11.9	(7)	25.8	28.1	29.4	(7)	46.3	48.3	52.1	(7)	9.0	9.7	10.7	(7)	19.3	20.3	22.2
12–13	(5)	12.1	12.4	12.9	(5)	26.0	27.3	28.2	(5)	45.2	47.2	49.6	(5)	9.5	10.0	10.6	(5)	19.9	21.0	22.0
13–14	(3)	13.7	13.8	13.9	(2)	25.9	27.1	28.3	(3)	47.5	48.2	49.2	(3)	8.8	9.1	9.5	(3)	19.1	19.5	20.2
14–15	(2)	14.2	14.3	14.4	(2)	25.3	26.0	26.6	(2)	45.1	45.6	46.1	(2)	9.4	9.5	9.6	(2)	21.3	21.4	21.5
15–16	(2)	15.0	15.2	15.3	(2)	26.3	26.4	26.4	(2)	46.0	46.9	47.9	(2)	8.5	8.6	8.7	(2)	19.7	20.0	20.2
17–18	(2)	17.0	17.0	17.1	(2)	26.8	26.9	27.0	(2)	47.8	48.3	48.8	(2)	9.1	9.3	9.5	(2)	19.4	20.5	21.6
58–59	(1)	—	58.4	—	(1)	—	21.0	—	(1)	—	42.4	—	(1)	—	9.4	—	(1)	—	22.6	—
61–62	(2)	61.0	61.3	61.6	(2)	21.4	21.4	21.5	(2)	41.2	43.0	44.7	(2)	9.0	9.4	9.7	(2)	18.5	18.6	18.7
146–147	(1)	—	146.8	—	(1)	—	28.8	—	(1)	—	42.2	—	—	—	—	—	—	—	—	—
188–189	(1)	—	189.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
193–194	(2)	193.0	193.5	194.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
202–203	(1)	—	202.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	(164)				(143)				(145)				(141)				(144)			

STANDARD LENGTHS IN CM.					PECTORAL LENGTH				VENTRAL LENGTH				LAST DORSAL RAY				DORSAL HEIGHT				ANAL HEIGHT			
Range		Min.	Mean	Max.		Min.	Mean	Max.		Min.	Mean	Max.		Min.	Mean	Max.		Min.	Mean	Max.		Min.	Mean	Max.
5–6	(47)	5.0	5.4	5.9	(36)	18.3	19.9	23.0	(36)	15.9	17.2	19.4	(38)	8.5	10.3	13.0	(29)	19.8	22.2	26.0	(28)	17.6	20.0	22.6
6–7	(7)	6.0	6.2	6.7	(7)	18.8	19.8	20.2	(7)	15.6	15.2	17.4	(7)	9.1	10.2	11.3	(7)	20.3	20.5	22.9	(6)	18.2	19.9	20.9
7–8	(17)	7.0	7.6	7.9	(11)	19.7	20.3	20.9	(13)	16.2	17.0	18.7	(16)	8.6	11.6	14.1	(6)	21.0	22.1	23.4	(6)	18.6	20.0	20.8
8–9	(26)	8.0	8.5	8.9	(20)	18.1	20.0	22.4	(20)	15.0	16.6	18.4	(22)	7.8	11.4	15.3	(18)	18.6	21.2	22.8	(17)	17.1	19.3	21.7
9–10	(26)	9.0	9.4	9.8	(21)	18.4	20.0	22.1	(21)	14.9	16.1	17.2	(25)	7.8	10.4	14.2	(20)	19.9	21.2	22.2	(21)	13.6	18.6	20.5
10–11	(9)	10.0	10.5	10.9	(6)	16.7	18.7	20.4	(5)	15.0	15.8	16.6	(6)	7.8	10.1	14.1	(6)	19.2	20.3	22.2	(6)	14.7	18.4	20.5
11–12	(7)	11.0	11.4	11.9	(4)	17.9	19.9	21.7	(5)	14.2	15.2	16.3	(7)	8.2	10.9	14.4	(4)	19.3	20.9	22.2	(4)	18.0	18.7	19.9
12–13	(5)	12.1	12.4	12.9	(2)	18.3	18.9	19.5	(2)	15.3	16.9	18.6	(4)	7.7	10.0	13.3	(2)	19.5	20.2	20.9	(2)	19.0	20.7	22.5
13–14	(3)	13.7	13.8	13.9	(3)	19.0	19.6	20.5	(3)	14.5	14.7	15.0	(2)	8.0	8.2	8.3	(3)	20.2	20.4	20.5	(3)	17.2	17.7	18.8
14–15	(2)	14.2	14.3	14.4	(2)	19.2	19.5	19.7	—	—	—	—	(2)	7.8	11.8	15.8	(1)	—	20.3	—	—	—	—	—
15–16	(2)	15.0	15.2	15.3	(2)	18.5	18.8	19.0	(2)	12.7	13.2	13.7	(1)	—	8.1	—	(2)	18.9	20.1	21.3	(1)	—	13.3	—
17–18	(2)	17.0	17.0	17.1	(1)	—	16.6	—	(2)	12.2	13.0	13.8	(1)	—	13.5	—	(2)	19.5	19.9	20.2	(1)	—	14.3	—
58–59	(1)	—	58.4	—	(2)	15.0	15.7	16.2	(1)	—	11.9	—	(1)	—	20.2	—	(1)	—	17.9	—	(1)	—	16.2	—
61–62	(2)	61.0	61.3	61.6	—	—	—	—	(2)	10.7	11.1	11.7	(2)	19.5	19.9	20.3	(2)	16.1	16.1	16.3	(2)	14.7	15.0	15.2
146–147	(1)	—	146.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
188–189	(1)	—	189.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
193–194	(2)	193.0	193.5	194.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
202–203	(1)	—	202.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	(164)				(117)				(119)				(134)				(103)				(98)			

the specimens than with gross errors of measurement. The latter item, the term "condition" of fisheries biologists, to which k is sometimes referred as the "coefficient of condition," would appear to be markedly variable in this species, a matter which field observation on the evident plumpness or leanness of individual specimens tends to support.

Since tarpon are not used for food, large numbers are not collected by commercial agencies, and since most anglers return their catches to the water, on a conservation basis, it is difficult to obtain large series of specimens for careful measurement. It is clear that sex and condition play an important role in the length-weight relationship of these fishes. If enough material with the sex known could be obtained, it would go far toward making possible the development of a more accurate expression of this relationship.

Probably for reasons similar to those mentioned above, surprisingly few taxonomic measurements on this fish have found their way into the literature. To help remedy this condition a series of 164 specimens was measured, covering the usual taxonomic measurements and some less usual. These are given in Table III. In a manner identical with Table I, the data have been broken up into size groups to indicate more certainly the slight variations in proportions that these fish undergo with growth. This was necessary, in addition, to separate clearly the smaller size groups, which have never been measured in any adequate manner before. Small tarpon, down to the smallest sizes in this series, resemble the large adults to a most remarkable degree. The only conspicuous difference, other than the slight shifts in various proportions, is the great elongation of the last dorsal ray shown by the larger specimens. In the smallest material this is scarcely longer than the next to the last ray, showing as a mere "point" at the end of the fin. It varies from a mean of about 10% of the standard length in the smallest to well over 20% in really large fish. The rather large amount of variation in the length of this ray, as indicated in Table III, is evidently due to mutilation and regeneration. Perhaps the maximum length it attains, rather than the mean, would be a better measure of the normal length of this element.

The meristic counts have fared no better in the literature. Table IV is a similar attempt to supply an adequate series of such measurements. The lateral series and the predorsals are shown comparatively. The most frequent occurrence is 44 in lateral scales and 24 predorsal scales. The clustering of the scatter about this point is evident. The arithmetic means are 44.3 and 23.5 respectively.

TABLE IV. COMPARISON OF TARPON SCALE AND FIN RAY COUNTS.

SCALES OF TARPON (71 specimens)

Predorsal scales	Lateral line scales						
	42	43	44	45	46	47	totals
21	1	2	1	—	—	—	*4*
22	1	—	7	5	2	—	*15*
23	—	7	1	4	—	—	*12*
24	1	4	9	8	3	1	*26*
25	—	2	3	6	1	—	*12*
26	—	—	1	1	—	—	*2*
totals	*3*	*15*	*22*	*24*	*6*	*1*	*71*

FIN RAYS OF TARPON[1] (139 specimens)

Dorsal fin	23	24	25	26	27	totals
15	—	2	—	—	2	*4*
16	1	12	20	20	18	*71*
17	—	4	29	21	10	*64*
totals	*1*	*18*	*49*	*41*	*30*	*139*

[1] All rays counted as one. See text for explanation.

The method of counting the fin rays in tarpon is evidently a matter that has led to some difficulty. As usually rendered in taxonomic descriptions, they appear as three or four less in both dorsal and anal counts than given in Table IV. In large fish the first four or five are consolidated into a solid leading edge, which have generally been counted as one ray. In the smallest sizes the separation of these rays is evident and doubtless, if small fish instead of large were generally available to taxonomists, the usage would have developed differently. In both anal and dorsal fins the rays, as here counted, appear as distinct when sufficiently prepared. The most frequent occurrence is 16 dorsal and 25 anal rays, as here counted. The arithmetic means are 16.4 and 25.5 respectively. The method of counting these fin rays has a curious bearing on the postlarval fish, which is discussed under that head. Taxonomic measurements taken from the literature are given comparatively in Table V. It is evident from this table that only Fowler (1936) gave the full dorsal and anal counts, indicating the number of consolidated rays by lower case roman numerals. Various other taxonomic characters not otherwise discussed herein are also given in this table.

LARVAL AND POSTLARVAL TARPON.

Tarpon in sizes below that at which they take on essentially the appearance of the adults are still not known with certainty. During these studies efforts were made to strip and fertilize the eggs of ripe speci-

TABLE V. TARPON COUNTS AND MEASUREMENTS FROM RECENT LITERATURE.

All measurements given in per cent. of standard length except as otherwise noted.

AUTHORITY	DORSAL	ANAL	L.L.[1]	P.D.[2]	OVER L.L.	UNDER L.L.	GILL-RAKERS	BR.[3]
Jordan & Evermann (1897)	12	20	42	—	—	—	—	—
Smith (1907)	12	20–23	Circa 45	—	12		—	23
Meek & Hildebrand (1923) and Hildebrand & Schroeder (1928)	12–15	20–23	42–47	—	—	—	? + 32–36	—
Beebe & Tee-Van (1928)	14	22	—	—	—	—	—	—
Nichols (1929)	12	19–20	42	—	—	—	—	—
Beebe & Tee-Van (1933)	12–15	19–23	42–47	—	—	—	—	—
Fowler (1936)	iv–v, 10–11	iv–v, 18–19	40–43 + 2–3	20–23	5	5–6	Circa 26[7] + 39	—
Present data	15–17	23–27	42–47	21–26	4	6	16–19 + 35–37	—
No. of specimens	(139)	(139)	(71)	(71)	(76)	(76)	(2)	—

AUTHORITY	HEAD	DEPTH	SNOUT	ORBIT	MAXILLARY	INTERORBIT.	PECTORAL LENGTH	LAST DORSAL RAY
Jordan & Evermann (1897)								
Smith (1907)	25[4]	25[4]	—	16[5] 66[6]	—	—	—	—
Meek & Hildebrand (1923) and Hildebrand & Schroeder (1928)	23.3–24.4	26.0–29.4	19.6–20.8[5]	21.5–25.6[5]	58.8–66.6[5]	—	6.2–9.2[5]	—
Beebe & Tee-Van (1928)	22.6–28.2	24.2–25.8	6.2– 7.4	4.1– 7.8	14.0–16.7	—	19.1–20.5	10.2–27.1
Nichols (1929)	25	26.3–27.0	—	22.2–22.7[5]	—	—	—	—
Beebe & Tee-Van (1933)	22.7–25.0	26.0–29.4	19.6–20.8[5]	21.5–25.6[5]	58.8–67.7[5]	—	—	—
Fowler (1936)	25.0–30.8	22.2–27.3	19.6–20.4[5]	21.5–29.4[5]	57.0–60.0[5]	18.2–20.0[5]	—	—
Present data	20.9–27.0	20.9–27.0	4.3– 9.3	3.5– 8.9	12.6–20.2	3.6– 6.3	15.0–23.0	7.7–20.3
No. of specimens	(146)	(126)	(143)	(152)	(147)	(144)	(117)	(134)

[1] Lateral line
[2] Predorsal scales
[3] Branchiostegal rays
[4] Per cent of total length
[5] Per cent of head
[6] Per cent of snout
[7] Probably a misprint for 16

mens. Males with running milt were obtained without difficulty but it was found impossible to obtain females with eggs in a sufficiently advanced stage to enable successful fertilization to be accomplished. It is true that anglers often take females from which eggs are running and which give the superficial appearance of being mature. Microscopic examination, however, shows that they are not entirely ripe and experiments have demonstrated that they are not yet ready for fertilization. Evidently the vigorous contortions that these fishes make on being boated cause a premature expulsion of the roe in well distended females approaching ripeness. It is possible, and not unlikely, that females thoroughly ripe do not feed until after spawning. Sexual maturity is reached in this region at a total length of about four feet (122 cm.). The smallest ripe female seen was 139.8 cm. on July 3. A fish with fully undeveloped gonads of 142.2 cm. t. l. was taken on June 22. This was the largest sexually immature specimen examined. See indication of this in Text-figure 1. At this size they weigh close to 20 kilograms.

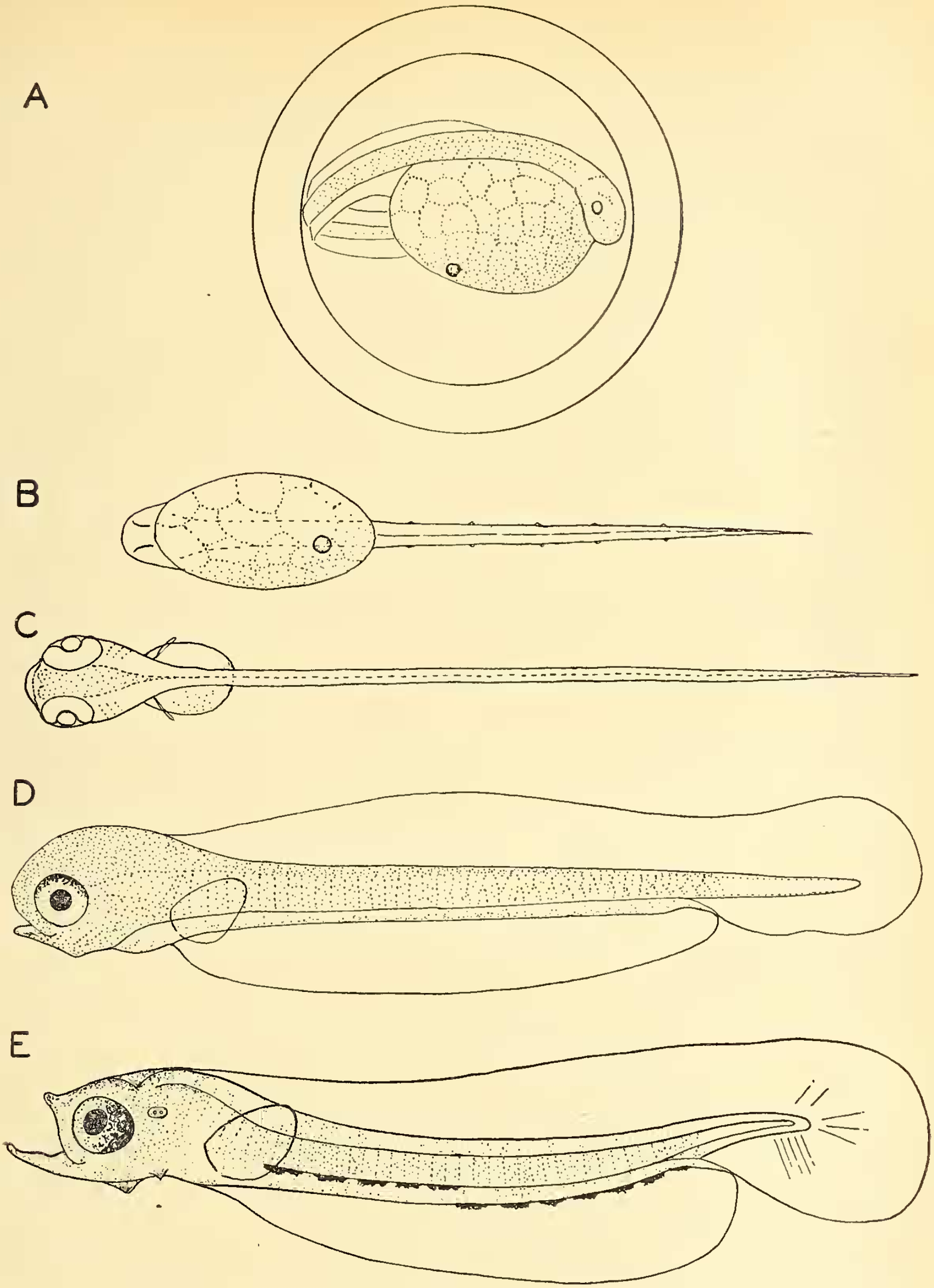
Since, during May, June and July at least, these fishes do spawn in the region as has been repeatedly observed in shallow water between the numerous islands, the eggs should be recoverable in tow-nets. Often pairs or three fish, evidently two males and one female, may be seen milling around, usually in water shallow enough to cause them to rile up the sand to a considerable extent. During this procedure white streaks or clouds appear, which are almost surely composed of quantities of milt emitted by the males. This was noted by Storey and Perry (1933) from near Sanibel and is in essential agreement with these personal observations. The sand pits described by Babcock (1936) may well be produced by spawning tarpon. Several were seen close to areas of unusual activity.

Tow-net operations at the surface have yielded no eggs that by any stretch of the imagination could be the eggs of tarpon as compared with the nearly ripe eggs taken from specimens. In this connection it was noted that these nearly ripe eggs sank in sea water even after they had water hardened, a fact first reported by Babcock (1936). Taking this as a hint, towing was undertaken close to the bottom in places near where tarpon were spawning. This method yielded very few eggs of any kind, but among them was one type that we have been unable to eliminate as clearly not that of the tarpon. Many such, in the aggregate, were taken during the years from 1938 to 1942 during the known spawning time of this species. Such an egg is shown in Text-figure 2, a. If this is not the egg of the tarpon it is surprisingly like what the nearly ripe eggs must approach on full development. These eggs averaged a little less than 2 mm. (1.8 mm.) in diameter. This compares with nearly ripe ovarian eggs which, when water-hardened, averaged nearly this size. Babcock (1936) gives 0.6 to 0.75 mm. for preserved ripe ovarian eggs, which agrees well with our data on the above. The eggs taken by tow-net sank in the sea water in which found, which had a specific gravity of 1.0140 at 25°. They just about floated in the denser off-shore water, where, in fact, eggs could sometimes be taken at the surface tows. They were, however, too disperse to collect in any numbers by the means available.

These eggs were hatched and carried on into larval development as far as was possible in the laboratory. The longest any were successfully held in a viable state even under elaborate care was a matter of three days. The various stages that these pass through up to that time are shown in Text-figure 2. The egg shown measured 1.7 mm. in diameter. The details of the other stages passed through are given in the legend to Text-figure 2. It will be noted that the most advanced stage shows characters not unlike those seen in the pre-leptocephalid larvae of apodal fishes and also that there has been considerable shrinkage in the length of the last two stages. Whether this is associated with its evident consolidation or is associated with unsatisfactory conditions in the laboratory bowls is uncertain.

There was more than the usual difficulty in rearing these larvae for reasons additional to their own delicacy. It so happens that the shore waters of this region are extremely rich in plankton, as has already been noted by Breder and Krumholz (1943). In fact, it is so rich that a glassful dipped from sea at the end of the laboratory dock looks slightly turbid and if held up to the light can be seen to be full of "jumping" minute crustacea. Some of these are extremely voracious and prey on the newly hatched fish from the numerous kinds of planktonic eggs. It was soon found impossible to rear anything hatched from such eggs without placing them in water that had been first filtered through cotton, for only a single organism was necessary to ruin a bowl of hatchlings.

It was noted that in these tows there was never any fish life except unhatched eggs and fairly large postlarvae. Knowing the time of hatching of numerous species, tows made at that time would sometimes yield shells, but never recognizable larvae. This was carefully checked on the easily recognizable and abundant eggs of *Anchoa mitchilli* (Cuvier and Valenciennes). These



TEXT-FIG. 2. Development of larval fish from an egg which may be that of *Tarpon atlanticus*. **A.** An egg as taken from tow-net catches made near the bottom, 1.7 mm. dia. **B.** Ventral view of a larva at the time of hatching, 3.0 mm. long. At this time they float passively in an inverted position. **C.** Dorsal view of a larva 24 hours from the time of hatching, 3.9 mm. long. By this time they have righted themselves and are active. **D.** Lateral view of a larva 43 hours from the time of hatching, 2.9 mm. in length. The eye has become pigmented, the yolk is nearly gone and the mouth is open and functioning and shrinkage has commenced. **E.** Lateral view of a larva 72 hours from the time of hatching, 1.9 mm. in length. Two series of chromatophores have appeared ventrally, the otic sapsule is evident and the eyes have become inclined somewhat forward. The gape has reached considerable size and the behavior is voracious. The general appearance approaches that of the pre-leptocephalus of apodal fishes.

are elliptical and even the empty shells may be recognized at once. This condition was found to be uniformly true for any of the species with which we were sufficiently familiar to make such determinations without difficulty. In the same tows would be found large numbers of the postlarvae in the sizes studied by Breder and Krumholz (1943). No variations from this condition were found in tows made in the "green" shore waters. However, when tows were made in the outside "blue" Gulf waters, the newly hatched larvae were taken in abundance. The chief obvious difference between these two colors of water is the relative abundance of plankton, the blue waters representing relatively "desert" conditions. Evidently most of the local species of pelagic egg producers spawn both within the blue and green waters, the delimitations of which make a surprisingly sharp line. Consequently it is deduced from this fact and the experiments with filtered water in the laboratory that few, if any, eggs hatching within the limits of the "passes" escape destruction on hatching. Those spawned in the blue waters evidently have a reasonable survival rate, because of the many fewer predators waiting for them, and it is evidently the postlarvae developing from these that work back into the inside waters at a size no longer vulnerable to the crustacean elements. Their presence there at this time, make the crustaceans their chief food, in turn. This leaves one with the conclusion that the spawning of such fishes in these shore waters is a complete peripheral wastage and that the only fishes successfully spawning, in Pine Island Sound, for example, are those which in some manner protect their young through this vulnerable stage from various planktonic elements. Checking through the species about which there is sufficient data, which fall within the latter categories, the following forms are listed together with their protective mechanism.

FISH. PROTECTION.

All Elasmobranchs
: Much too large at birth or hatching

Bagre marinus (Mitchill)
Galeichthys felis (Linnaeus)
: Oral incubators and with eggs and young too large at hatching and release.

All Cyprinodontidae
: Too large and advanced at hatching.

All Poeciliidae
: Too large and advanced at birth.

Strongylura notata (Poey)
Hyporhamphus unifasciatus (Ranzani)
: Too large and advanced at hatching.

All *Syngnathus*
All *Hippocampus*
: Too large and advanced on release from brood pouch.

All Atherinidae
: Too large and advanced on hatching.

Bathygobius soporator (Cuvier and Valenciennes)
: Protected by parent in a shell cavity remote from the pelagic crustaceans.

Gobiosoma robustum Ginsburg
: Same as preceding.

Opsanus beta Goode and Bean
: Same as preceding and in addition too large at hatching.

Paraclinus marmoratus (Steindachner)
: Protected by parent in lumen or cavities of a sponge and remote from pelagic crustacea.

This list covers all species of which we have positive knowledge of spawning in the Sound, many, by their natures, being practically confined to such places. All the others, pelagic egg producers, are also found in outside waters. It would thus appear that fishes here have two possible courses in regard to reproduction. If producing pelagic eggs, hatching at an early time into small fragile larvae, they must have recourse to at least some reproductive activity in outside waters. Such is evidently the case. The other course, breeding only within the inside "green" waters, can only be specifically successful if some morphologic, developmental or behavioristic habit insures the protection of the young until they are too large to be preyed upon by planktonic elements.

The tarpon has clearly taken the first-mentioned course and only in the "blue" outside waters have larvae of the eggs, that may be those of this species, been taken. None have been taken beyond the size of those reared in the laboratory, the finding of which should lead to their positive or negative identification as tarpon. Clearly this approach to the postlarval tarpon has been no more successful than the attempt of an approach from the larger sizes down, but it does indicate that the larvae developing from this egg, whether tarpon or not, does not move into the estuarine waters as soon as of sufficient size, as do many of the others.

Almost certainly this missing and perhaps off-shore stage is a leptocephalus, as would be expected from general considerations and the fact that the eastern near relative, *Megalops cyprinoides* (Broussonet), has had such a stage identified. Since the leptocephali of this species have been taken in places not unlike the waters well within Pine Island Sound, van Kampen (1909), an intensive search by all methods available to us has been undertaken. This included towing extensively in all manner of likely and unlikely places, dredging the bottom with small fish trawls, using night lights both from docks and afloat and even digging in sandy and muddy places where amphioxus was found. This last examination was instigated by Mr. Stewart Springer, who said that he once saw something along with the amphioxi that may have been a leptocephalus. No such specimens were found. After five years of this exploratory effort in both summer and winter, it would seem fair to assume that the leptocephali are not to be found regularly in these inside places.

In attempting to carry on the larvae from the eggs supposed to be those of *Tarpon*, a variety of treatments were given, including reducing the salinity of the water and transfer to fresh water from pools in which young tarpon lived. In none of these experiments was there either an improvement or impairment of viability that could be noted. The latter is the more remarkable since other pelagic eggs similarly treated promptly died. Included in these were *Anchoa, Paralichthys, Lactophrys* as well as many others not fully identified. Extensive towing in the lower reaches of the Peace River and in numerous ponds produced no such eggs. A single pool, on Captiva Island, into which high surf washed over a low sand ridge, contained both adult *Anchoa* and their eggs, but nothing was seen of the supposed tarpon eggs.

Hildebrand (1934) recorded what he believed to be a young tarpon in the transition from leptocephalus to adult form. Unfortunately this specimen, which was taken at the mouth of Core Creek, Beaufort, North Carolina, was inadvertently destroyed before a figure was made of it, with the result that all that is now available is the brief description given by Hildebrand. There is no reason to suppose that it is not the young of the tarpon, except for a peculiar feature of the fin ray counts. Hildebrand gives dorsal 12 and anal 20. It so happens that these are the counts generally given by taxonomists on adult material, as is shown in Table V. As pointed out in the section on the body proportions of tarpon, in the smaller sizes, of three inches and under, the extra rays are clearly evident. It would seem that surely the counts to be found in a transforming leptocephalus of this species would be, dorsal 15 to 17 and anal 23 to 27. No doubt at this stage and size, 2 cm., some of these rays destined to become consolidated are relatively small, although in the smallest specimens available they actually grade up to the longest ray in each fin. Hildebrand in a personal communication stated that "... the figures given, I am sure, were based on the total number of rays (or fulcra) visible under magnification." This specimen, then, could hardly be the young of the tarpon, unless there is some unexpectedly late development of these elements. The other two possibilities, *Elops saurus* and *Albula vulpes*, are clearly eliminated on the bases of their much different fin counts, as has been indicated by Hildebrand. The Beaufort region is well out of tarpon country, except as a place for strays to turn up, as also is indicated by Hildebrand. It thus is conceivable that this might equally well be a stray from most any place south of North Carolina and might be referable to some other isospondyle, although what could possibly be a suitable form is not evident. It thus appears that this specimen must rest as a probable, but uncertain, record until more material serves to clarify the fin count matter.

Juvenile Tarpon.

Tarpon are next known from fishes from about 5 cm. upwards. The smallest that we have obtained measures 4.2 cm. in standard length. Various features of these sizes are given in Tables I, II, III, VI and X. Table VI indicates the sizes of the small ones that Mr. Bishop actually saw entering a small pool from the open sea. A second small sample taken twelve days later from this same place, then land-locked, suggests that as a group they showed a mean growth of a little over 2 cm. which is not out of line with what one might expect of a species reaching such a large size. The actual growth rates of some individual fish under a variety of conditions is given in Table VII. These are all fully positive records of marked individuals and serve to indicate the response in growth variation that these fishes show to various kinds of environments. It has been long suspected that the tarpon found in small land-locked pools may be stunted. The first part of the table indicates that certain individuals under such conditions may show no growth whatever in periods up to and over five months. In respect to growth these fish are comparable to those kept in aquaria of various sizes, which is in reasonable accord with what one would expect from the evident mean growth of those taken as they entered such places.

In this same table are given calculations of the rates of increment in length, reduced to a standard annual basis, for purposes of comparison with the apparent increase of the fishes measured in Table VI. From this it is clear that the smallest tarpon, evidently just out of the leptocephalus stage, are growing at a relatively terrific rate, but as soon as they reach the size of the smallest otherwise to be found in this pool they drop down to a relatively slow growth. Those kept in the laboratory pool and in small aquaria showed a mean growth of the same sort, while those in the Sanibel pools showed marked stunting, as already mentioned. These relationships are indicated in Text-figure 5.

Larger specimens kept at the old New York Aquarium showed a higher growth

TABLE VI. MEASUREMENTS OF COLLECTIONS OF THE SMALLEST TARPON.

These include the smallest specimens of definite record. They were collected, on the first date, just as they entered a pond on Sanibel Island, from the Sea.

Cm. standard lengths	NUMBER OF SPECIMENS Aug. 8, 1939	Aug. 20, 1939
4.2	1	–
4.9	1	–
5.0	5	–
5.1	1	–
5.2	4	–
5.3	8	–
5.4	8	–
5.5	5	–
5.6	2	–
5.7	5	–
5.8	5	–
5.9	3	–
6.0	2	–
6.1	–	–
6.2	1	–
6.3	–	–
6.4	–	–
6.5	–	–
6.6	–	–
6.7	1	–
6.8	–	–
6.9	–	–
7.0	–	1
7.1	–	–
7.2	–	–
7.3	–	–
7.4	–	3
7.5	–	2
7.6	–	3
7.7	–	2
7.8	–	3
7.9	–	1
8.0	2	2
8.1	–	–
8.2	–	1
8.3	–	2
8.4	–	2
8.5	–	1
8.6	–	–
8.7	–	1
8.8	–	–
8.9	–	–
9.0	1	–
9.1	–	1
9.2	1	–
9.3	–	1
9.4	–	–
9.5	1	–
9.6	–	–
9.7	–	–
9.8	–	1
10.1	1	–
10.6	1	–
11.2	1	–

Date	Maximum	Mean	Minimum
8/8/39	*11.2*	6.0	*4.2*
8/20/39	*9.8*	8.0	*7.0*
Measurements in cm. total lengths.			
8/8/39	*14.7*	7.7	*5.8*
8/20/39	*12.7*	10.3	*8.9*

TABLE VII. FULLY POSITIVE RECORDS OF TARPON GROWTH.

All measurements in cm. total length.

Initial date	Initial length	Final length	Elapsed days	Increment	Growth rate[1]	Tag number
7/11/38	34.5	39.0	258	4.5	18.5	15038
7/20/38	37.0	38.0	167	1.0	5.9	15136
8/ 4/38	36.0	36.0	152	0.0	0.0	15137
8/23/38	35.5	35.5	133	0.0	0.0	15129
8/23/38	36.5	36.5	133	0.0	0.0	15124
The first listed in a small pond two miles north of St. James City, Pine Island, "A" in text-figure 2. The rest in a pond three and one-quarter miles north-west of Point Ybel, Sanibel Island, "B" in text-figure 2.						
3/26/39	24.0	33.0	472	9.0	29.0	13420
3/26/39	28.0	29.3	472	4.2	11.6	13421
3/25/39	23.0	33.6	427	10.6	39.4	13422
3/30/39	35.0	52.9	468	17.9	39.9	13424
12/31/41	43.6	46.5	183	2.9	13.3	—
The above released in the laboratory pool on Palmetto Key on initial date.						
LABORATORY SPECIMENS						
At the New York Aquarium						Aquarium no.
9/28/39	9.8	11.7	314	1.9	22.5	1
9/28/39	11.0	12.7	314	1.7	17.9	1
9/28/39	12.0	15.7	314	3.7	35.8	1
9/28/39	14.5	17.5	314	3.0	24.1	1
9/28/39	9.4	11.7	222	2.3	40.2	2
9/28/39	10.6	13.0	314	2.4	26.3	2
9/28/39	11.4	13.5	113	2.1	59.6	2
9/28/39	13.2	16.7	314	3.5	30.8	2
9/28/39	9.5	11.0	314	1.5	18.4	3
9/28/39	10.1	11.5	222	1.4	22.8	3
9/28/39	10.2	12.7	314	2.5	28.5	3
9/28/39	10.8	12.5	314	1.7	18.3	3
The above kept in aquaria of standing sea water, 24″ x 12″ x 12″. Specific gravity 1.024. Temperature 22 to 24° C. Water 10″ deep.						

COMPARATIVE GROWTH RATES OF TARPON

Based on the above fully positive records.

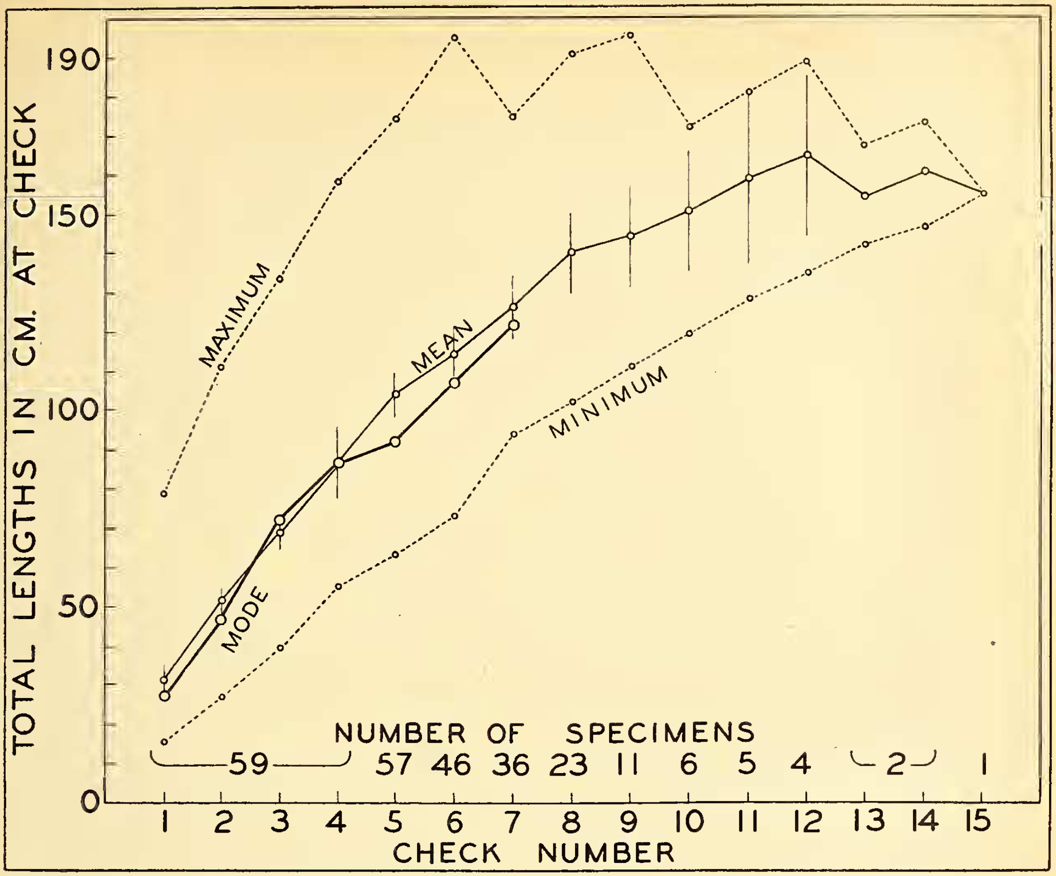
Location	Number of fish	Mean initial length	Mean growth rate
Pine Island "A"	1	34.5	18.5
Sanibel Island "B"	4	36.2	1.5
Laboratory pool	5	30.7	26.6
Aquarium 1	4	11.8	25.1
Aquarium 2	4	11.2	39.2
Aquarium 3	4	10.2	22.0
All Aquaria (1, 2 & 3)	12	11.1	28.8
Sanibel (newly arrived) (See Table VI)		7.7	616.2

[1] Rate calculated as % of increase in total length for one year, according to the following formula:

$$X = \frac{\frac{I}{T} \cdot 36500}{L}$$

In which

L = Initial length
I = Increment
T = Elapsed days
X = Calculated rate of increase



TEXT-FIG. 3. Length of tarpon at the time of development of checks on the scales (annulae?). Based on imprints in celluloid of large scales. The numerical data are given in Table XII. The limits of variation are indicated by the dotted lines marked "Maximum" and "Minimum." Twice the standard error of the means, in both plus and minus directions, is indicated by vertical lines in classes of four or more fish. The number of specimens in each class are indicated below the curve. The values of the mode are indicated by a heavier line than that used for the means down to a lower limit of thirty-six fish below which clear modes could not be established.

rate but still comparable to that of the smaller fish kept in small aquaria and in the laboratory pool. These specimens kept on exhibition at the old New York Aquarium grew from less than 50 cm. up to 122 cm. in a period of five years, see Table XIV. These fish were taken near Key West, Florida. More exact measurements were out of the question because of the demands of exhibition.

The accumulated data of others on the occurrence of small tarpon are given in Table XI. Included with the data of Storey and Perry (1933) is the statement that young tarpon were taken April, 1933, of 8.46 and 12.70 cm. These are not much larger than those we took from another place on Sanibel Island in August at the time of their entry. It may be that these fish had been there a year, as they suggested, but with the demonstrated lack of growth that sometimes occurs at that place it is possible that they are much older.

SCALE ANALYSIS.

The useful method of counting the checks on the scales of fishes as an index of years passed has never been critically investigated in subtropical marine species, although they show markings that could be so interpreted if a sound basis for such a view could be established. In an effort to cast some light on the nature of the checks on tarpon scales, both experimental study and statistical analysis were applied in order to determine if there is any regularity and any statistical significance assignable to these marks.

Certain specimens were taken in land-locked pools, tagged and recaptured at a later date. The data so obtained are given in

Table VIII. Checks on the Scales of Tarpon on Which There are Fully Positive Records of Growth.

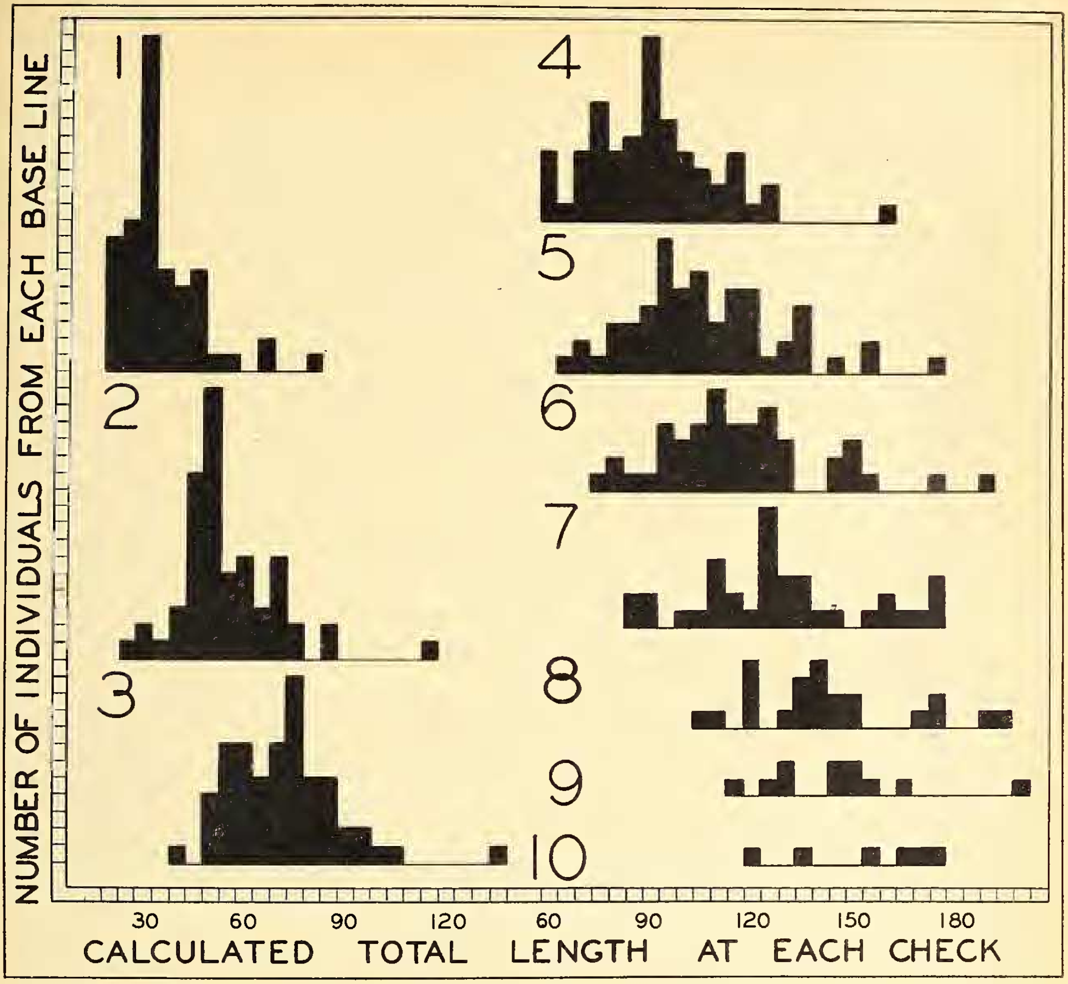
All measurements in cm. total length.
Scale edges in italics between columns of check calculations.

Tag number	Date of scale removal	1	2		3		4		5	
15038	7/11/38	15.0	22.4		27.5	*34.5*				
	3/26/39	11.3	21.8		31.8		36.0	*39.0*		
	Mean	*13.1*	*22.1*		*29.6*		*36.0*			
15136	7/20/38	13.1	19.4		26.2		33.6	*37.0*		
	8/23/38	9.8	16.9		28.4		32.5	*37.0*		
	1/30/39	8.9	17.5		22.8		31.2		35.0	*38.0*
	Mean	*10.6*	*17.9*		*25.8*		*32.4*		*35.0*	
15137	8/ 4/38	20.1	30.7		33.4	*36.0*				
	1/30/39	16.8	26.9		33.5	*36.0*				
	Mean	*18.5*	*28.8*		*33.5*					
15129	8/23/38	15.1	23.2		25.9		29.8		32.0	*35.5*
	1/30/39	12.3	21.9		25.4		29.8		32.5	*35.5*
	Mean	*13.7*	*22.5*		*25.6*		*29.8*		*32.2*	
15124	8/23/38	11.5	20.4		30.1		33.7	*36.5*		
	1/30/39	11.6	20.1		29.3		32.9	*36.5*		
	Mean	*11.5*	*20.2*		*29.7*		*33.3*			
L. pool	12/31/41	18.8	31.0	*43.6*						
	7/ 1/42	18.4	29.5		41.8	*46.5*				
	Mean	*18.6*	*30.2*		*41.8*					

Table VII. Compared with these data in the same table is similar information on specimens held in aquaria. The markings on the scales of these fishes are given in Tables VIII and IX. Measurements of the markings on the scales of large fish are given in Table XII as proportional parts of the total length of the fish. The total length has been used for this study of the scale markings, as it was found impractical to attempt to induce anglers and others that were kind enough to help, to take measurements in standard lengths. For purposes of conversion Table I, showing the relationship between the total and the standard length, should be consulted.

The values given in Table XII, plotted out according to the number of recognizable checks, are shown in Text-figure 3 on the assumption that they represent some natural regularity in time. The appearance of the mean, maximum and minimum values present a not unreasonable growth curve. Following the methods of Westman and Fahy (1940) and Westman and Gilbert (1941), twice the standard error of the mean is indicated by verticals in both directions. This gives a measure of the significance attached to these values. Large irregularities are no doubt accounted for by the fact that it was impossible to determine the sex in most cases and undoubtedly some of the checks measured are adventitious rings which would make the fish appear older than it was in fact. The excess of the maximum values over the minimum as referred to the mean may be a measure of such sources of error. As a further expression of the extent of the regularity of these check marks, Text-figure 4 shows histograms of each of the checks of the fishes given in Table XII. The values of these modes is shown in Text-figure 3 comparatively with the mean values and clearly shows substantial agreement. There is thus clearly some distinguishable regularity in time of the formation of these checks. Furthermore they show a regular decrease in spacing with increase in number, which in other and northern fishes is taken to represent the effects of the slowing down of length increment with age in an environment which is responsible for the formation of such checks at uniform intervals of time. The question that then remains is whether this effect on the tarpon scale is in the nature of an annual event or not. This calls for an analysis of changes in the tarpon environment of an annual or other nature.

Most students have hesitated to assign the term annulae to marks on the scales of the more southern species on the basis that the annual change in temperature of the sea or other influences was perhaps insufficient to cause the formation of such checks. Insofar as the fishes of the Florida west coast are concerned, this would seem to be an unwarranted assumption for here in these coastal waters there is a considerable seasonal temperature change. In fact, periodically it drops to lows sufficient to kill large numbers of fishes. See for example Willcox (1887), Brown (1905), Finch (1917), Storey and Gudger (1936), Babcock (1936), Storey (1937). See also Taylor (1917) who discusses other causes of sudden mortality in this region. Gunter (1941) discusses low temperatures on the Texas



TEXT-FIG. 4. Histograms of checks on scales given in Table XII and Text-figure 3, indicating modes, distribution and spread with increasing number. Each class covers 5 cm., the upper limit of which is indicated. The left index indicates units of one fish.

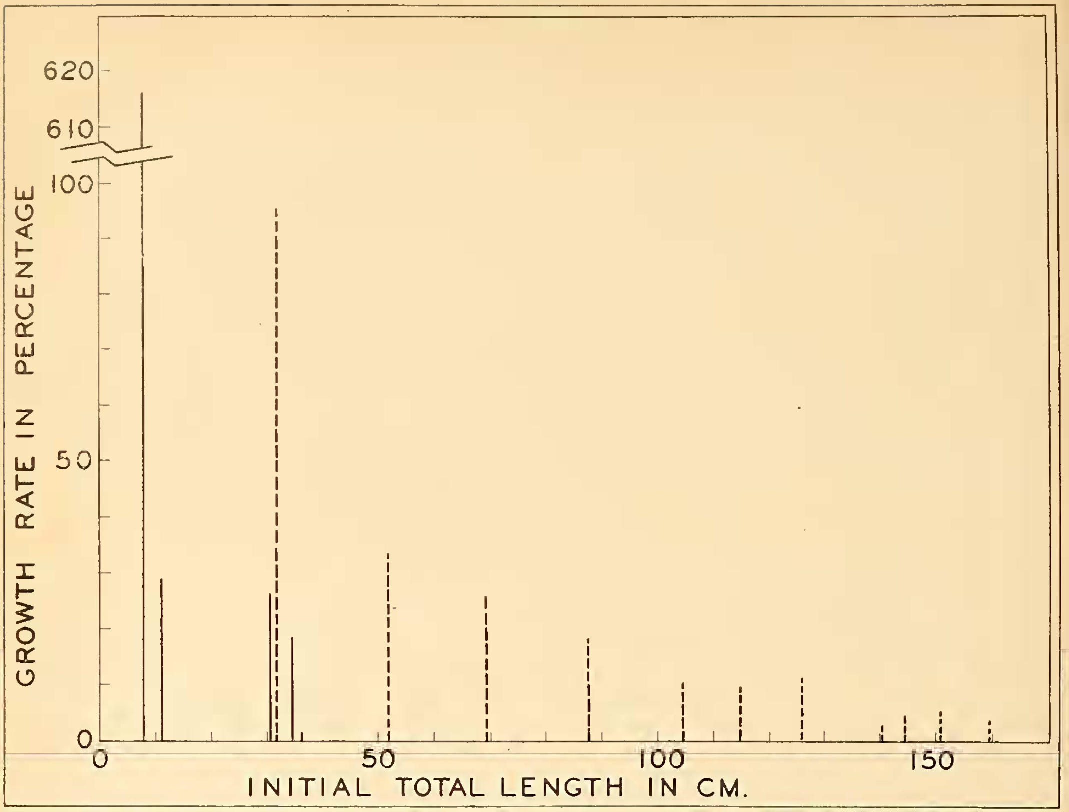
coast bearing on similar matters. Temperature records made at the end of the laboratory dock show the following differences between summer and winter.

TEMPERATURES AT LABORATORY DOCK IN °C.

	Max.	Mean	Min.
June 4 to July 11, 1940, 41, 42 (148 readings) . .	*33.7*	30.8	*26.5*
March 5 to 31, 1941 (26 readings)	*22.2*	19.5	*15.0*

It should be evident from the above tabulation alone that there is a considerable temperature change with the seasons at this place. This is even more marked in backwaters and streams that are much frequented by tarpon. A glance at Text-figure 8 gives some idea of the access of these estuarine waters to the open Gulf at the laboratory site. In addition to simple temperature change there is a large change in the fauna with the seasons. Many fishes are absent or nearly so in winter or summer and the invertebrate faunal change is most striking. It would seem likely that there is a consequently large dietary change with the season, which might influence the whole physiology of the fish.

Other factors that must be reckoned with are those of movements of the fish themselves. There is a considerable movement in and out of streams by these fishes. If there is any regularity to it we have not been able to determine such. At this writing it appears to be entirely sporadic. Local lore is to the effect that tarpon that have been recently in fresh water have a slightly "golden" tinge and that those which have not are "pure silver." Two such color phases are readily distinguished at sight and check



TEXT-FIG. 5. Growth rates of fully positive records of individual tarpon under various conditions compared with the indicated growth rate of large fish according to the formula

$$\frac{\frac{I}{T} \cdot 36500}{L} = X$$

based on the data of Tables VI, VII and X. Solid lines, rates of fully positive records. Dotted lines, rates of large fish based on scale readings.

was kept to determine if one showed a predominance at any season. Nothing of such a nature was noted and the two kinds appeared in roughly equal numbers. As many small specimens were kept in aquaria, both fresh and salt, credence is given to this fisherman's belief because those kept in fresh water took on a "brassy" color while those in salt water remained "silvery white." Furthermore it is a common occurrence for many fishes, in passing from salt to fresh water, to lose even more of their bright silvery color and to regain it on returning to the sea, e.g. *Petromyzon* and *Salmo*. This is evidently some physiological matter, perhaps associated with calcium metabolism. If this movement in and out of fresh or nearly fresh water is reflected in the scales, we have no indication of it. Small tarpon can easily withstand a transfer from straight fresh water to sea water of more than normal density or vice versa. Experimentally they did not throw down a check after such treatment.

Migrations proper, which the tarpon are supposed to make but of which we have as yet no good experimental evidence, would hardly be expected to produce other than "winter rings" in season. The general hypothesis is that they move northward along the Florida west coast and down the Texas coast and back across open waters. Even if this is true they would be exposed annually to a marked temperature differential.

There is thus established the fact that tarpon are exposed to annual fluctuations of temperature of considerable sort, and they cannot be thought of as living continually in an environment of uniform temperature. The above statements refer to tarpon in open waters. Obviously those confined to small land-locked pools suffer even greater extremes of temperature.

In order to attempt to determine if it were justifiable to consider these markings as winter rings, scales of various marked fish were examined at various periods. The results in calculated length at the time the various checks were formed are shown in Table VIII. It will be noted that in each case where a fish passed through a winter, an additional check was formed except in the case of the three fish from Sanibel Island which showed no growth at all and therefore could not form a new check. This table also gives a measure of the extent of accuracy to be expected from measurements and calculations of this kind from tarpon scales. The measurements made on different scales from the same fish, taken at different times, show for most part rather close agreement. The largest deviation from the mean value is in no case greater than 24% and in most cases under 5%.

Growth rates of these measured fish are shown comparatively with similar data from Table XII. Further data of a similar nature on large numbers of small fish are given in Table XIV and the evident growth of these various groups of land-locked specimens is expressed graphically in Text-figure 6. It will be noted that the growth characteristics vary widely from pool to pool and agree with those from which two scale samples had been taken. Compare especially the Pine Island with the Sanibel fishes.

Finally there have been the fishes kept for several years at the old New York Aquarium. These were held under practically uniform conditions as to temperature and food, in salt water. The data on their growth and scale markings are given in Table XIV and shown graphically in Text-figure 7, compared with the mean values of scales of large fish, taken from Text-figure 3. From this it is obvious that they were growing at a rate comparable with those in the sea. These fish were taken in a body of water open to the sea near Key West and presumably had not been stunted. Two of these, the upper two in Text-figure 7, passed 5 and 4 winters at the Aquarium respectively and showed one check mark for each winter passed. The third, lowest in Text-figure 7, and consequently the smallest, showed 6 checks as against 4 winters passed in the Aquarium. If it is assumed that all had no checks before capture, then it must follow that the checks agree with the number of winters passed through except in the case of one fish that in some way developed two "adventitious" rings. In this connection, when these tarpon arrived at the Aquarium, one died during handling. Its scales were examined for rings and none were found, Breder (1937). Since these markings and the sizes of the fish agree so well with the marks on the scales of large fish, it is difficult not to believe that these marks are in truth winter rings in the ordinary sense of the word. Since, however, the formation of

TABLE IX. DETAILED RECORD OF GROWTH OF CERTAIN INDIVIDUAL SPECIMENS OF TARPON.

All measurements in cm. total length
AQUARIUM SPECIMENS (See Table VII)

Initial date 9/28/39	Second date 113 days	Third date 201 days	First increment	Second increment	Growth rate (1)	Growth rate (2)
9.8	10.5	11.7	0.7	1.2	23.1	20.8
11.0	11.5	12.7	0.5	1.2	14.7	18.9
12.0	14.0	15.7	2.0	1.7	53.8	22.1
14.5	16.0	17.5	1.5	1.5	33.4	17.0
9.4	11.0	11.7[1]	1.6	0.7	55.0	21.3
10.6	11.3	13.0	0.7	1.7	21.3	27.3
11.4	13.5	—	2.1	—	59.6	—
13.2	15.5	16.7	2.3	1.2	56.3	14.1
9.5	10.5	11.0	1.0	0.5	34.0	8.6
10.1	11.2	11.5[1]	1.1	0.3	35.2	8.9
10.2	11.5	12.7	1.3	1.2	31.4	18.9
10.8	11.5	12.5	0.7	1.0	20.9	15.8
			Maximum		*59.6*	*27.3*
			Mean		36.6	17.6
			Minimum		*14.7*	*8.6*

OCCURRENCE OF CHECKS ON SCALES OF ABOVE LISTED FISHES

Date	Number of fish	Number of checks 0	1	2	Total lengths at check number: 1 Max.	Mean	Min.	2 Max.	Mean	Min.
First	12	7	5	0	*12.4*	8.9	*5.1*	—	—	—
Second	11	0	11	0	*13.4*	9.8	*9.1*	—	—	—
Third	10	0	8	1	*11.8*	9.5	*8.4*	—	13.5	—

[1] Figures marked with footnote 1 in third column represent 109 days instead of 201.

TABLE X. SIZE GROUPS OF TAGGED TARPON BY LOCALITY AND DATE.

Measurements in cm. total length.
Modes in 5 cm. intervals—the upper limit indicated.

LOCALITY	DATE	NO. OF FISH	LENGTHS IN CM. Max.	Mean	Mode	Min.
Pine Island, one to two miles north of St. James City (ditch)	7/ 6/38	32	*51.5*	34.4	35	*27.5*
	7/11/38	7	*77.4*	61.5	65	*34.5*
	2/26/39	4	*61.0*	34.0	—	*23.0*
	3/ 7/39	3	*23.5*	25.7	—	*27.0*
Sanibel Island, 1 mile s. of Wulfert (pond)	8/ 9/38	2	*66.0*	65.5	—	*65.0*
Sanibel Island, ½ mile s.w. of Point Ybel (ditch)	8/ 2/38	1	—	35.5	—	—
	8/ 4/38	47	*48.0*	37.1	35	*31.0*
	8/ 9/38	37	*66.5*	39.8	35	*32.0*
	8/25/38	45	*49.0*	36.5	35	*31.0*
	3/30/39	5	*37.5*	35.9	—	*35.0*
Sanibel Island, 3¼ miles s.w. of Point Ybel (pond)	7/20/38	36	*42.5*	35.1	40	*32.0*
	8/ 2/38	54	*42.0*	35.9	40	*32.0*
	8/ 4/38	24	*38.5*	35.8	40	*33.0*
	8/23/38	46	*41.0*	36.0	40	*31.5*
	8/24/38	22	*38.5*	35.9	40	*32.0*
	1/30/39	10	*38.0*	35.6	—	*33.5*
Boca Grande Island, Railroad ditch 2 miles north of city	6/28/38	1	—	37.5	—	—
	6/30/38	2	*66.5*	56.7	—	*47.0*
	7/ 4/38	1	—	58.0	—	—
Captiva Island near Redfish Pass (pond)	8/18/38	1	—	40.0	—	—
Boca Grande Pass	7/ 6/38	3	*167.6*	144.8	—	*127.0*
	7/ 7/38	2	*187.9*	153.6	—	*119.4*
	7/ 9/38	1	—	152.5	—	—
	3/23/39	2	*130.9*	122.4	—	*113.9*
	3/24/39	6	*122.0*	114.3	—	*106.9*
	3/28/39	1	—	114.3	—	—
	4/ 4/39	1	—	101.7	—	—
	4/ 9/39	2	*167.6*	140.9	—	*114.3*
	4/16/39	1	—	107.8	—	—
	4/20/39	1	—	137.2	—	—
	4/21/39	2	*132.2*	104.2	—	*76.3*
	4/22/39	1	—	165.2	—	—
	4/25/39	1	—	183.0	—	—
	4/26/39	1	—	107.8	—	—
	4/28/39	2	*183.0*	152.4	—	*121.9*
	4/30/39	3	*198.1*	183.4	—	*156.1*
	5/ 1/39	2	*152.6*	137.3	—	*122.0*
	5/ 2/39	1	—	122.0	—	—
	5/ 3/39	1	—	137.2	—	—
	5/ 4/39	1	—	152.6	—	—
	5/ 5/39	2	*183.0*	180.4	—	*177.8*
	5/ 6/39	2	*198.1*	152.5	—	*106.9*
	5/13/39	1	—	137.2	—	—
	5/14/39	1	—	152.5	—	—
	5/18/39	1	—	152.6	—	—
	5/20/39	1	—	127.0	—	—
	5/22/39	2	*167.8*	155.0	—	*142.2*
	5/23/39	2	*198.1*	—	—	*183.0*
	5/25/39	1	—	183.0	—	—
	5/28/39	1	—	175.2	—	—
	6/ 2/39	1	—	193.2	—	—
	6/ 3/39	1	—	122.0	—	—
	6/ 5/39	1	—	122.0	—	—
	7/28/39	1	—	152.6	—	—
	8/ 7/39	2	*177.8*	169.9	—	*122.0*
	8/11/39	1	—	167.8	—	—

TABLE X. (CONTINUED)—SIZE GROUPS OF TAGGED TARPON BY LOCALITY AND DATE.

LOCALITY	DATE	NO. OF FISH	LENGTHS IN CM. Max.	Mean	Mode	Min.
Captiva Pass	7/12/38	1	—	127.0	—	—
	7/13/38	2	*137.1*	129.5	—	*121.9*
	7/14/38	1	—	119.5	—	—
	3/26/39	3	*137.2*	126.3	—	*109.3*
	4/ 9/39	1	—	139.6	—	—
	5/ 1/39	2	*195.7*	174.1	—	*152.6*
	8/ 6/39	2	*137.2*	129.6	—	*122.0*
	8/ 9/39	1	—	137.2	—	—
	8/10/39	1	—	101.8	—	—
Redfish Pass	5/15/39	1	—	101.7	—	—
Off Palmetto Key	7/10/39	1	—	137.5	—	—

these rings took place under the abnormally uniform conditions of an aquarium, some source other than some obscure physiological regularity may be sought. The only variable entering into this situation that was not controlled was that of hours of daylight, which is evidently the only item that could account for this situation. As this feature of environment is well established as having similar effects, it may be assumed, subject to further experimentation, that this accounts for the check formation. The fact that electric lights were lighted over the tanks on dark days would be presumably altogether too insignificant to be expected to have any measurable effect. Text-figure 7 also shows the growth of the smallest wild fish of which there is any record; the data of Table VI. This fits nicely with the rest, especially when it is borne in mind that this growth is probably minimal, due to the fact that these fish were newly trapped on Sanibel Island where it is known that growth is slow or even absent.

These data, compared with those already discussed on long term land-locked fish, show clearly that fish from open waters grow at relatively greatly accelerated rates and that there is little in common with the check formations on the scales from the two types of environment. From this it follows that the land-locked forms have little to do with the stock of maturing fishes. No scales from larger fishes have been found that show checks at the small sizes as those from land-locked places. The latter must therefore be looked upon as a peripheral wastage not taking part in the main stock, evidently few escaping from such places to grow up to be large fish, which is in agreement with the opinions of Babcock (1936).

Another approach to an attempt to under-

TABLE XI. ACCUMULATED RECORDS OF SMALL TARPON.

AUTHORITY	SIZES IN CM.[1]	LOCALITY	DATE
Evermann & Marsh (1902)	19-29.1 s.l.?	Huacares, Porto Rico	February
Eigenmann (1902 & 1921)[2]	2-19.2 s.l.?	Pinar del Rio, Cuba	March
Coker (1921a)	25 s.l.?	Dauphin Island, Alabama	January
Coker (1921b)	5.7-6.0 s.l.	Fajardo, Porto Rico	———
Beebe (1927 & 1928) &	5.1-20.3 s. l.	Source Matelas, Haiti	January 13
Beebe & Tee-Van (1928)	7.6-33.1 s.l.	Source Matelas, Hait	January 23
	11.4-17.8 s.l.	Source Matelas, Haiti	March 21
Breder (1933)	15.5-28.0 s.l.	Andros Island, Bahamas	February
Storey & Perry (1933)	12-38 s.l.?	Sanibel Island, Florida	"Any time"
	8.5-17.7 s.l.?	Sanibel Island, Florida	April
Babcock (1936)[3]	27.5-47.9 t.l.?	Boca Grande, Florida	———
	20.3-35 t.l.?	Shark River, Florida	February
	1-4 lbs.	St. James City, Florida	———
	small	Grenada, Jamaica	———
	7.6 t.l.?	Aransas Pass, Texas	———
	25.4 t.l.?	Cristobal, Canal Zone	———
Breder (1937)	circa 15.2-22.8 s.l.	Key West, Florida	June
Breder (1939c)[4]	Upwards from less than 6.0 s.l.	Sanibel Island, Florida	August
Original[5]	31.1-32.4 s.l.	Chagres River, Canal Zone	April

[1]Various measures converted to cm. standard length where practicable.

[2]The smallest, 2 cm., has never been located as a preserved specimen and there is some question as to whether this is a misprint. See Babcock (1936) for a discussion of this specimen.

[3]This author quotes and discusses many of these records and those of larger fish.

[4]Actually 4.2 to 11.2 s.l. See Table VI.

[5]From data and photographs obtained from Mr. William Markham. Evidently the same location as those of Babcock's Canal Zone records.

TABLE XII. CALCULATIONS OF SIZE AT TIME CHECKS WERE FORMED, BASED ON CELLULOID IMPRINTS OF LARGE TARPON SCALES.

Date collected	Calculated total lengths in cm. at check number:[1]															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
7/ 3/38	37.6	49.3	71.5	88.0	98.7	111.8	122.0	133.9	147.0	163.2	170.1	178.4	*182.0*			
7/ 6/38	19.6	52.5	72.2	85.3	102.6	117.8	135.3	*139.7*	—	—	—	—	—	—	—	—
7/ 6/38	21.0	40.6	63.5	81.6	102.0	117.9	*127.0*	—	—	—	—	—	—	—	—	—
7/11/38	43.5	65.3	87.0	96.8	114.1	129.5	*137.4*	—	—	—	—	—	—	—	—	—
7/13/38	38.2	61.5	72.6	83.9	94.9	115.5	*122.2*	—	—	—	—	—	—	—	—	—
7/13/38	37.2	54.3	78.4	99.5	109.5	*119.5*	—	—	—	—	—	—	—	—	—	—
7/14/38	32.0	40.5	50.1	69.3	77.7	*92.8*	—	—	—	—	—	—	—	—	—	—
3/23/39	28.4	45.9	72.3	100.7	*113.8*	—	—	—	—	—	—	—	—	—	—	—
3/23/39	27.5	47.4	63.2	92.5	117.4	*130.9*	—	—	—	—	—	—	—	—	—	—
3/24/39	27.2	44.5	52.5	64.5	76.5	*106.8*	—	—	—	—	—	—	—	—	—	—
3/24/39	28.4	49.4	72.8	87.9	98.6	112.7	*122.0*	—	—	—	—	—	—	—	—	—
3/24/39	42.4	56.9	77.2	89.5	101.7	109.8	*122.0*	—	—	—	—	—	—	—	—	—
3/24/39	25.8	46.9	75.0	86.7	96.0	105.3	112.4	117.2	*121.9*	—	—	—	—	—	—	—
3/24/39	16.0	66.7	74.6	88.0	96.0	*106.7*	—	—	—	—	—	—	—	—	—	—
3/26/39	30.2	45.7	55.9	86.5	104.9	114.1	126.9	*137.2*	—	—	—	—	—	—	—	—
3/26/39	33.1	45.7	55.9	68.6	88.0	99.3	*109.2*	—	—	—	—	—	—	—	—	—
3/26/39	30.5	45.7	57.4	66.1	81.3	99.1	104.2	116.9	*132.1*	—	—	—	—	—	—	—
3/28/39	23.8	40.5	57.1	66.5	78.5	88.0	100.0	*111.8*	—	—	—	—	—	—	—	—
4/ 3/39	60.8	70.7	79.6	93.9	105.0	108.2	120.5	*126.0*	—	—	—	—	—	—	—	—
4/ 4/39	23.5	41.2	53.8	70.6	86.4	94.2	*101.8*	—	—	—	—	—	—	—	—	—
4/ 9/39	19.6	56.8	70.0	96.2	110.7	*139.7*	—	—	—	—	—	—	—	—	—	—
4/ 9/39	41.8	72.6	97.7	122.8	134.0	145.1	156.2	*167.5*	—	—	—	—	—	—	—	—
4/ 9/39	29.4	49.1	55.0	70.6	88.3	96.4	105.9	*111.9*	—	—	—	—	—	—	—	—
4/20/39	27.8	30.0	47.1	55.7	70.7	83.5	87.9	115.8	128.6	*137.2*	—	—	—	—	—	—
4/21/39	26.4	46.3	59.5	72.6	90.2	101.2	110.2	127.6	*132.1*	—	—	—	—	—	—	—
4/23/39	51.2	59.6	68.3	89.5	115.1	121.5	134.2	144.9	162.0	172.5	181.2	189.9	*198.1*	—	—	—
4/25/39	23.8	38.1	52.8	59.5	69.2	78.6	85.5	102.3	123.8	133.2	142.7	157.0	167.5	173.5	*185.4*	—
4/27/39	26.2	50.0	71.4	85.6	118.9	150.0	171.2	*185.5*	—	—	—	—	—	—	—	—
4/28/39	18.7	31.2	53.3	75.1	90.5	103.2	*121.9*	—	—	—	—	—	—	—	—	—
4/28/39	25.8	55.8	86.1	111.8	129.0	148.3	163.3	172.1	*182.9*	—	—	—	—	—	—	—
5/ 1/39	43.1	66.3	92.9	112.9	129.2	151.0	166.0	191.0	196.0	*204.0*	—	—	—	—	—	—
5/ 1/39	42.9	60.2	68.3	85.7	107.0	120.6	132.7	148.7	*158.0*	—	—	—	—	—	—	—
5/ 1/39	28.8	65.8	78.3	90.6	111.2	127.5	142.0	*152.3*	—	—	—	—	—	—	—	—
5/ 2/39	22.4	47.4	69.7	102.3	117.0	*127.0*	—	—	—	—	—	—	—	—	—	—
5/ 2/39	18.2	43.7	58.3	78.2	91.0	105.5	116.3	*121.9*	—	—	—	—	—	—	—	—
5/ 3/39	25.4	49.7	63.0	73.0	85.2	94.0	108.5	*126.0*	—	—	—	—	—	—	—	—
5/ 4/39	42.7	51.3	61.2	78.3	91.2	106.9	122.5	135.3	149.5	*158.0*	—	—	—	—	—	—
5/ 5/39	46.7	80.0	93.5	113.6	133.8	143.8	157.5	170.5	*180.4*	—	—	—	—	—	—	—
5/ 5/39	64.3	83.5	102.5	118.5	144.2	173.2	*182.9*	—	—	—	—	—	—	—	—	—
5/13/39	27.4	47.1	80.3	90.1	105.9	119.0	129.4	*137.2*	—	—	—	—	—	—	—	—
5/14/39	20.8	53.4	72.0	84.6	92.9	104.5	120.8	134.8	144.0	*152.3*	—	—	—	—	—	—
5/18/39	19.0	42.8	65.6	80.4	93.1	105.8	120.7	139.5	*152.3*	—	—	—	—	—	—	—
5/18/39	79.4	111.1	133.9	158.8	174.5	195.0	*204.0*	—	—	—	—	—	—	—	—	—
5/22/39	39.6	65.6	83.9	96.9	111.9	121.2	128.2	137.5	*142.4*	—	—	—	—	—	—	—
5/23/39	26.5	59.4	83.1	92.3	114.0	123.4	133.0	142.4	152.0	166.2	175.5	*182.9*	—	—	—	—
5/25/39	25.4	43.8	69.4	92.5	115.7	129.5	153.0	168.9	*182.9*	—	—	—	—	—	—	—

5/28/39	31.8	47.7	66.5	124.8	154.0	*175.2*	—	—	—	—	—	—	—	—	—	—
6/ 2/39	29.2	64.4	87.7	105.2	122.8	140.3	172.5	187.2	*193.0*	—	—	—	—	—	—	—
6/ 5/39	29.9	42.7	57.7	70.5	81.2	92.0	109.0	*121.9*	—	—	—	—	—	—	—	—
6/26/40	21.9	55.1	76.5	110.1	131.2	146.1	—	—	—	—	—	—	—	—	—	—
6/27/40	27.8	67.7	83.5	106.8	132.2	*147.3*	—	—	—	—	—	—	—	—	—	—
6/27/40	37.6	46.0	71.2	83.4	96.5	112.9	123.4	137.8	142.2	150.6	*158.8*	—	—	—	—	—
6/28/40	27.4	37.8	48.5	59.1	67.5	75.9	84.8	147.7	*151.8*	—	—	—	—	—	—	—
7/ 4/40	24.5	42.7	73.9	104.7	*118.1*	—	—	—	—	—	—	—	—	—	—	—
6/ 9/41	20.6	41.2	50.6	87.4	151.4	*165.2*	—	—	—	—	—	—	—	—	—	—
6/ 9/41	17.8	27.7	47.5	71.5	83.2	95.0	106.8	116.9	126.7	*138.5*	—	—	—	—	—	—
6/ 9/41	28.4	39.1	48.0	71.9	104.7	122.1	175.0	*176.6*	—	—	—	—	—	—	—	—
6/22/41	31.4	50.4	64.9	77.5	92.3	104.6	121.3	131.9	*142.3*	—	—	—	—	—	—	—
6/26/41	17.6	23.9	40.0	57.5	63.9	73.5	84.5	105.4	111.8	120.0	129.3	135.8	142.1	147.0	155.0	*161.3*
Means	*31.1*	*51.8*	*69.4*	*87.9*	*104.3*	*114.9*	*126.2*	*140.2*	*144.0*	*150.9*	*159.8*	*165.4*	*154.8*	*160.2*	*155.0*	—
Standard error	±1.6	±1.9	±2.1	±4.6	±3.0	±3.5	±4.2	±5.0	±6.5	±7.7	±11.2	±10.4	—	—	—	—
Maximum	79.4	111.1	133.9	158.8	174.5	195.0	175.0	191.0	196.9	172.5	181.2	189.9	167.5	173.5	—	—
Minimum	16.0	27.7	40.0	55.7	63.9	73.5	84.5	102.3	111.8	120.0	129.3	135.8	142.1	147.0	—	—
No. of spec.	59	59	59	59	57	46	36	23	11	6	5	4	2	2	1	0
Growth rate[2]	—	95.5	33.9	25.7	18.7	10.1	9.9	11.1	2.7	4.8	5.8	3.5	—	—	—	—

[1] Total lengths (scale edges) given in italics after last check, but not included in the mean calculations.
[2] Calculations as in Table VII. See text for full explanation.

Table XIII. Size of Large Tarpon Compared With Number of Checks on Scales.

Number of fish	Number of checks[1]	Max.	Total lengths in cm. Mean	Min.
2	4	*118.1*	115.9	*113.8*
11	5	*175.2*	132.5 ± 7.3	*92.8*
10	6	*204.0*	135.0 ± 9.8	*101.8*
13	7	*185.5*	139.7 ± 6.4	*111.8*
12	8	*193.0*	156.0 ± 6.5	*121.9*
5	9	*204.0*	158.0 ± 10.9	*137.2*
1	10	—	158.8	—
1	11	—	182.9	—
2	12	*198.1*	190.1	*182.1*
1	14	—	185.4	—
1	15	—	161.3	—

[1] Exclusive of the scale edge.

stand the checks on tarpon scales is to compare the total number of checks on a scale with the length of the fish from which taken. These data are given in Table XIII for the fish listed in Table XII. They are compared with data of other smaller fishes from various places in Text-figure 8. Considering the large fish as a random angler's sample, it is clear that the bulk of the fishes caught have 7 checks and evidently have passed through that many winters. Since at this age they show a mean length of 139.7 cm. and we have obtained sexually immature fish as large as 142.2 cm. and the smallest ripe fish at 139.8 cm., it is evident that the time of greatest hazard, as far as capture by angling is concerned, is just at about the time of first spawning. Further, just about as many are caught below this age as above it, i.e. 36 of this size or less and 33 above it, in Table XIII.

Comparison with the small land-locked specimens shows the same kind of separation already noted in the earlier treatment, while the aquarium specimens fall within or close to the range of the large fish.

Movements of Tarpon.

The actual data on which this analysis is based are expressed in various forms in Tables XV and XVI and are summarized in Table XVII. Much of the tagging was of an experimental nature, undertaken to determine the suitability of tags, the nature of growth in small land-locked ponds and similar matters. Such fish were not available to the general angling and fishing public and consequently no returns could be expected from these, which numbered 226 tagged fish.

Those which were available to the public numbered 254 tagged fish. Of these 177 were small land-locked specimens released in the open sea or bays and 77 were large "angler's" fish, released where caught except for 3 which were taken from Boca Grande Pass and subsequently released at Palmetto Key. Thirteen tags taken from fish

TABLE XIV. CALCULATIONS FROM THE STUDY OF THE SCALES OF SMALL TARPON.

No. of specimens in parenthesis. Standard errors after means.

A. CALCULATIONS OF SIZE AT TIME CHECKS WERE FORMED, BASED ON SCALES OF SMALL LAND-LOCKED TARPON

Calculated total lengths in cm. at check number:

1 Max.	1 Mean	1 Mode	1 Min.	2 Max.	2 Mean	2 Mode	2 Min.	3 Max.	3 Mean	3 Mode	3 Min.	4 Max.	4 Mean	4 Mode	4 Min.
Pine Island 1938															
(36) 37.2	22.5±1.1	22.5	8.5	(12) 52.0	35.2±2.6	—	13.3	(6) 55.4	44.6±2.8	—	18.9	(5) 63.1	51.0±4.5	—	26.6[1]
Pine Island 1939															
(1) —	20.7	—													
Sanibel Island, Wulfert 1938															
(2) 40.4	38.2	—	36.0	(2) 54.2	49.7	—	45.3	(2) 60.1	55.6	—	51.1	(1) —	61.5	—	—
Sanibel Island, ½ mile s.w. of Point Ybel 1938															
(110) 38.4	27.6±0.5	27.5	17.5	(36) 39.9	32.7±0.7	32.5	25.5	(3) 37.6	34.6	—	31.7				
Sanibel Island, ½ mile s.w. of Point Ybel 1939															
(3) 28.1	20.8	—	16.1	(2) 32.5	31.8	—	31.1								
Sanibel Island, 3¼ miles s.w. of Point Ybel 1938															
(146) 37.8	27.5±0.5	32.5	10.1	(70) 40.2	31.4±0.5	32.5	21.1	(12) 36.0	32.8±0.8	32.5	30.2	(1) —	28.3	—	—
Sanibel Island, 3¼ miles s.w. of Point Ybel 1939															
(10) 35.6	23.5±2.1	22.5	12.5	(8) 33.2	27.5±1.4	27.5	20.6	(2) 33.2	30.4	—	27.6				
Captiva Island, near Redfish Pass 1938															
(1) —	20.2	—	—												
Laboratory Pool, Palmetto Key 1940															
(5) 27.4	22.4±1.9	—	15.0	(5) 43.3	35.6±1.9	—	31.2	48.0	44.3	—	40.6				
Gasparilla Island, Railroad ditch 1938															
(4) 35.2	28.1±2.5	—	21.2	(4) 42.0	38.0±0.6	—	37.5	(2) 48.8	48.3	—	47.8				

[1] Continues as 5: (2) 72.6 52.9—33.2 6: (1) 41.6 7: (1) 47.4 8: (1) 55.0 9: (1) 60.0 10: (1) 65.4 11: (1) 68.3 12: (1) 73.0.

B. SIZE AND NUMBER OF CHECKS ON SMALL TARPON

Total lengths in cm. according to check number:

0 Max.	0 Mean	0 Mode	0 Min.	1 Max.	1 Mean	1 Mode	1 Min.	2 Max.	2 Mean	2 Mode	2 Min.	3 Max.	3 Mean	3 Mode	3 Min.
Pine Island 1938															
—	—	—	—	(24) 46.0	34.1±1.0	32.5	23.0	(6) 51.5	34.7±3.2	32.5	27.5	(1) —	61.5[1]	—	—
Pine Island 1939															
(5) 27.0	25.1	—	23.0												
Sanibel Island, Wulfert 1938															
—	—	—	—	—	—	—	—	(1) —	66.0	—	—	(1) —	65.0	—	—
Sanibel Island, ½ mile s.w. of Point Ybel 1938															
(5) 41.0	37.0±1.2	—	34.5	(74) 45.5	36.1±0.5	37.5	31.0	(33) 48.0	38.0±0.9	37.5	31.0	(1) —	38.5[2]	—	—

Sanibel Island, ½ mile s.w. of Point Ybel 1939															
—	—	—	—	(1) —	32.0	—	—	(2) *35.0*	35.0	—	*35.0*				
Sanibel Island, 3¼ miles s.w. of Point Ybel 1938															
(3) *36.0*	34.0	—	*33.5*	(76) *40.0*	35.9±0.2	37.5	*32.0*	(58) *42.0*	35.8±0.3	37.5	*32.5*	(11) *37.5*	35.8±0.4	—	*33.5*[3]
Sanibel Island, 3¼ miles s.w. of Point Ybel 1939															
—	—	—	—	(2) *38.0*	36.5	—	*35.0*	(6) *37.0*	35.1±0.5	—	*33.5*	(2) *37.5*	35.5	—	*33.5*
Captiva Island, near Redfish Pass 1938															
—	—	—	—	(1) —	40.0	—	—								
Laboratory Pool, Palmetto Key 1940															
—	—	—	—	—	—	—	—	(4) *40.6*	37.8±0.9	—	*35.6*	(1) —	56.2	—	—
Gasparilla Island, Railroad ditch 1938															
—	—	—	—	—	—	—	—	(2) *47.0*	45.0	—	*43.0*	(2) *61.5*	59.7	—	*58.0*

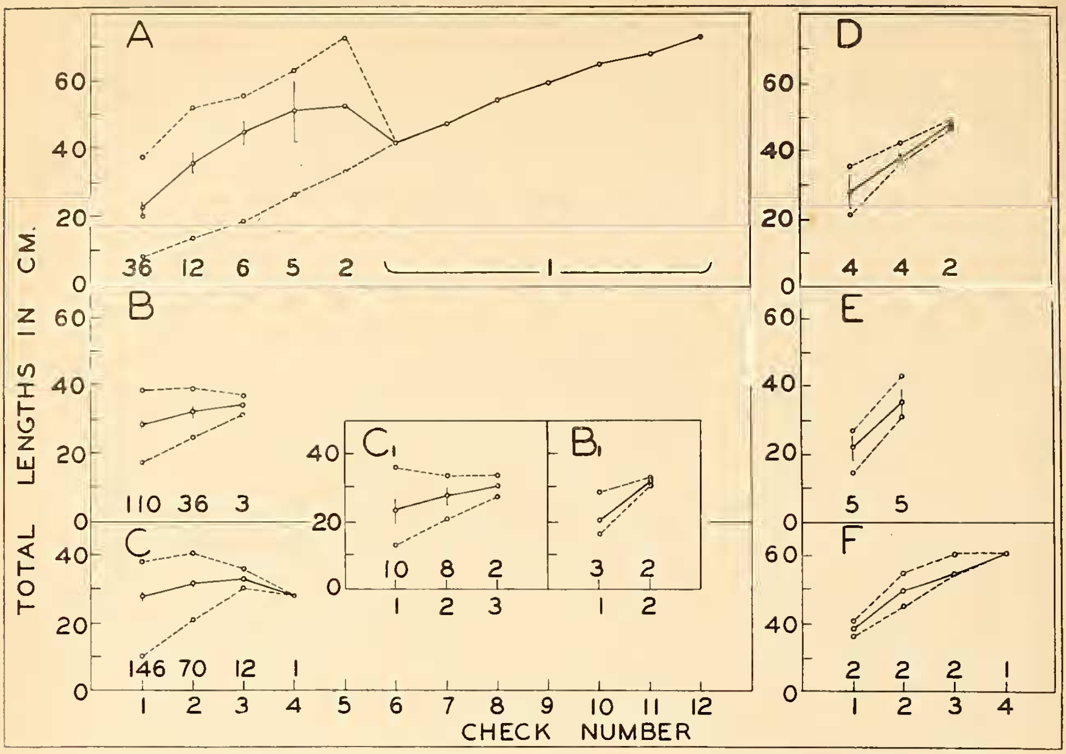
[1] Continues 4: (3) 62.0 61.3 60.0 5: (1) 77.5 11: (1) 73.0
[2] Continues 4: (1) 45.5
[3] Continues 4: (1) 34.0

C. SCALE IMPRINTS OF TARPON NOT IN TABLE XII

Scale edges (total lengths) given in italics after last check.

Total lengths in cm. at check number:

1	2	3	4	5	6	7	8	9	10	11	12
Laboratory Pool, Palmetto Key 7/1/40											
24.5	43.3	48.0	*56.2*	—	—	—	—	—	—	—	—
27.4	37.4	*40.6*	—	—	—	—	—	—	—	—	—
24.6	33.5	*38.2*	—	—	—	—	—	—	—	—	—
15.0	32.8	*36.8*	—	—	—	—	—	—	—	—	—
20.6	31.2	*35.6*	—	—	—	—	—	—	—	—	—
Sanibel Island, Wulfert 8/9/38											
36.0	45.3	51.1	61.5	*65.0*	—	—	—	—	—	—	—
40.4	54.2	60.1	*66.0*	—	—	—	—	—	—	—	—
Gasparilla Island. Dates as below.											
28.1	37.5	47.8	*58.0*	—		7/ 4/38	—	—	—	—	—
21.2	32.5	*47.0*	—	—		6/30/38	—	—	—	—	—
35.2	42.0	48.8	*61.5*	—		6/30/38	—	—	—	—	—
28.0	40.0	*43.0*	—	—		6/28/38	—	—	—	—	—
Pine Island 7/11/38											
25.0	34.6	48.0	*61.5*	—	—	—	—	—	—	—	—
19.2	35.4	50.7	63.1	72.6	*77.5*	—	—	—	—	—	—
26.0	38.4	47.5	57.3	*60.0*	—	—	—	—	—	—	—
32.1	52.0	55.4	58.6	*62.0*	—	—	—	—	—	—	—
28.7	40.6	47.2	59.2	*62.0*	—	—	—	—	—	—	—
8.5	13.3	18.9	26.6	33.2	41.6	47.4	55.0	60.6	65.4	68.3	*73.0*
Aquarium fish. Initial length <50.0 from 1/10/36 to date given.											
44.0	67.8	84.6	102.0	115.0	*122.0*	11/2/41	—	—	—	—	—
25.7	34.2	42.8	51.4	62.1	70.6	*74.9* est.	8/1/40	—	—	—	—
36.4	44.2	52.9	66.3	*74.9*	—	9/10/40	—	—	—	—	—



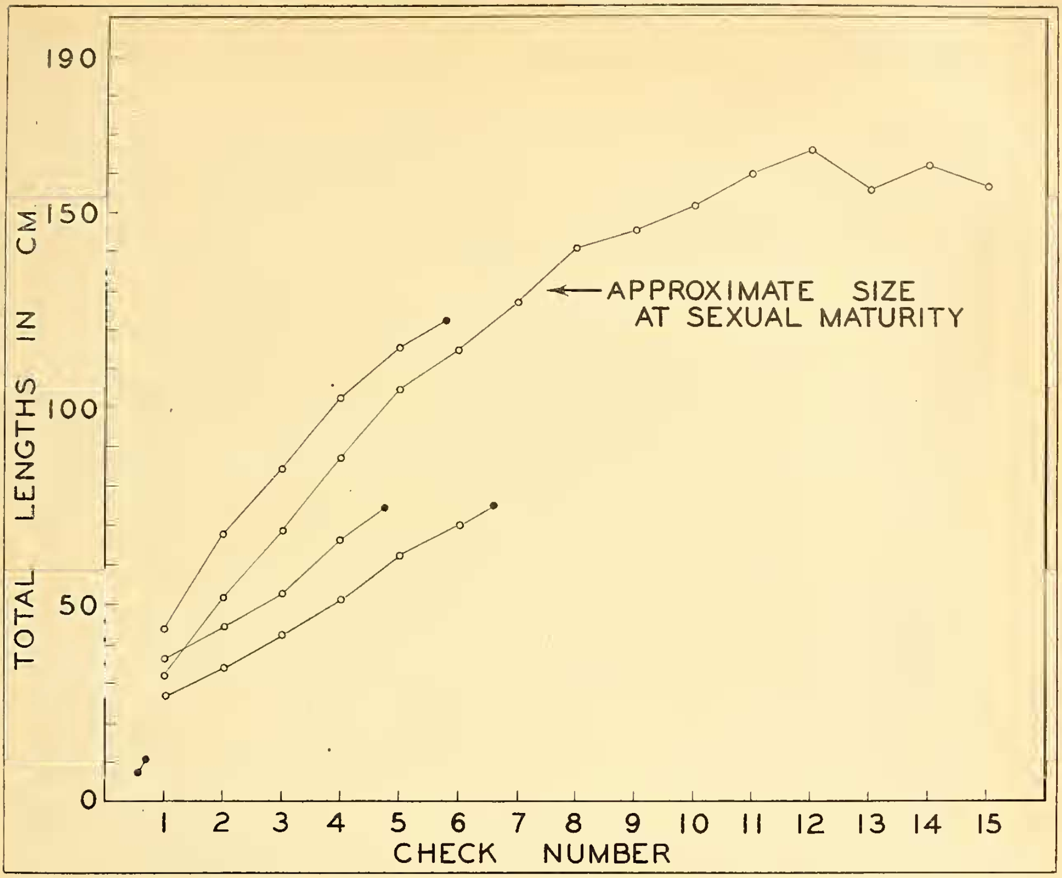
TEXT-FIG. 6. Length of land-locked tarpon at the time of the development of checks on the scales (annulae?). Based on the direct examination of scales. The numerical data are given in Table XIV. Notation as in Text-figure 3. **A.** Pine Island, 1938, and single fish, 1939. **B.** Sanibel Island, ½ mile s.w. Point Ybel, 1938. **B₁.** Same, 1939. **C.** Sanibel Island, 3 miles s.w. Point Ybel, 1938. **C₁.** Same, 1939. **D.** Gasparilla Island, 1938. **E.** Laboratory pool, Palmetto Key, 1940. **F.** Sanibel Island, Wulfert, 1938.

were returned by various fishermen to the Government offices by their finders, as shown in the schedule comprising Table XVI.

Recoveries from open waters amount to 5+% while recoveries from land-locked places amounted to 4–%. Of the former 1+% represents larger "angler's" fish and 7–% represents small fish which were taken in land-locked places and released in open waters. The details of these data are given in Table XVII.

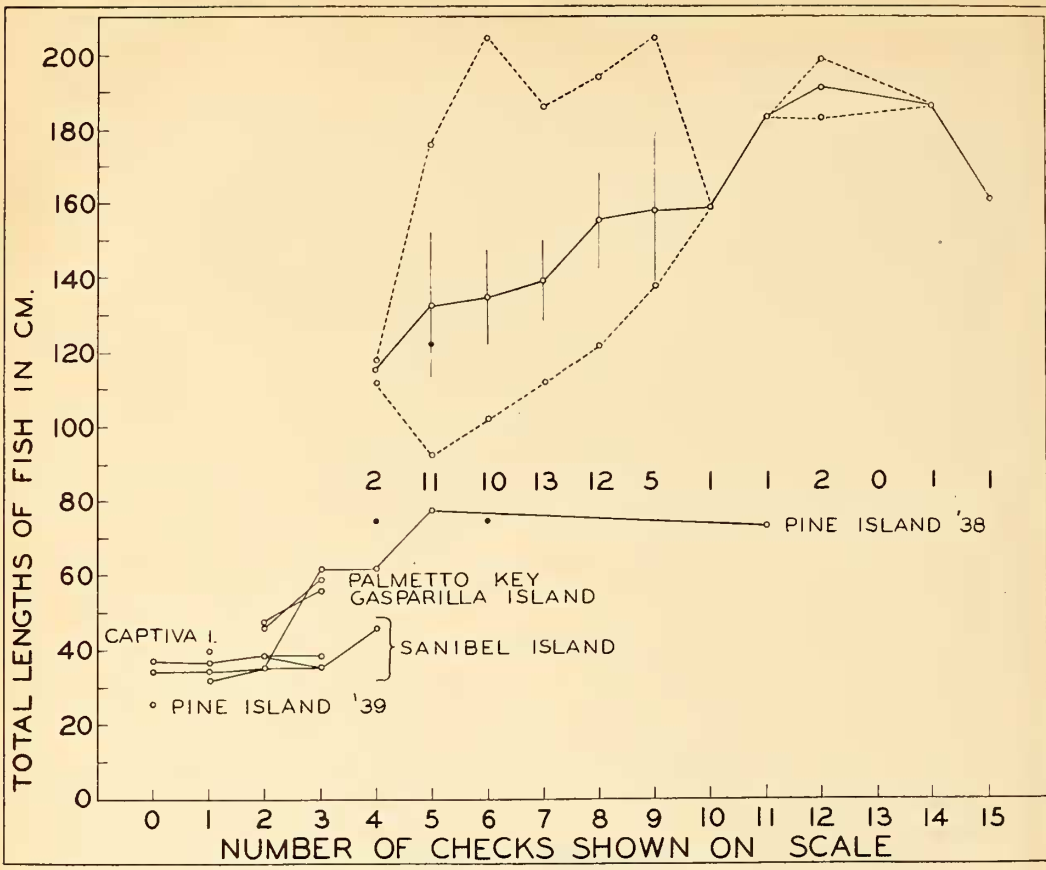
Since the latest land-locked fish to be recovered had all cast their tags in something over a year, it is to be presumed that the wild ones showed a complete loss in at least the time that has elapsed since then and at present there are no tarpon bearing our tags. A consideration of Table XVI shows that actually the last fish in open waters known to be still bearing its tag was taken 118 days after tagging. Two longer records refer to cast tags picked up on Sanibel beach, while a third is uncertain as to date. The greatest known length of time for a tag to be retained in a land-locked pool is 258 days for tag no. 15038 in Table VII.

While these data are many too few to base any final conclusions upon, as far as they go they would indicate that retention of either button or strap tags cannot be expected to exceed eight months. Also the loss of tags in pools and the open sea would evidently seem to be about equal in speed. There is no evidence of any unknown intercommunication between the open waters and the supposedly land-locked pools. Such connections are evidently irregularly intermittent due to storms or other changes, as generally supposed. Although most local people and anglers claim that small tarpon are extremely rare, a condition which we did not find borne out in the light of the material collected, we found that all but one of the returns pertained to relatively small tarpon of a size that most people disclaimed any knowledge of ever seeing. Obviously, however, the catchers of these fish must have been angling for other fishes, such as squeteague, for example, or using small seines. That a return of 7–% was obtained by such means would suggest on face value slight loss of tarpons in these size groups incidental to fishing operations



TEXT-FIG. 7. Comparison of known growth of three tarpon in aquaria and the smallest wild fish with the mean values given in Text-figure 3. Numerical data given in Tables VI, XII and XIV. Notation as in Text-figure 3. Dark circles represent measured lengths of fishes and are placed according to date on the assumption that the checks (open circles) represent winters.

for other species. However, since there is such unanimity of opinion concerning the absence of these small sizes, our inability to find such in open waters after prolonged combing of the region would clearly indicate their substantial absence from places frequented by fishermen. It must be recalled that these tagged fish were removed from pools to open water and were thus made available to fishermen by our activities. The low return on the larger fish, 1 out of 77 tagged, would seem to indicate a very small take of the available stock, for here there is a vigorous and active angling fraternity that does catch larger numbers of tarpon in the course of a year, as evidence the records of the hotels at Useppa Island and Boca Grande alone. Consequently there is no indication from this of evidence that the present rate of catch of tarpon as a sportsman's fish is in any way depleting the stock. Furthermore it must be borne in mind that a goodly proportion of the fishes are released without ever having been fully removed from the water. While the fate of the majority of these is uncertain, undoubtedly a considerable number survive. Suggestive in this connection are the experimental data obtained on laboratory fishes discussed by Shlaifer (1941). Two chief hazards would seem to appear. One, a physiological matter, includes the shock effect so marked on handling tarpon and the amount of success they have in regaining sufficient composure to take the necessary first breath after release. Since most of the tarpon are released in fairly open or deep water and we know the chief hazard to their continued survival at such times to be the proximity of soft flocculent mud, there should not be much loss from this source unless the continued "playing" of the fish or some unknown condition in the large adults or their environment comes into action, working toward their destruction. The second factor involves the presence



TEXT-FIG. 8. Length of tarpon compared with number of checks (annulae?) on scales. From data of Table XIII and XIV. Notation for large fish as in Text-figure 2. The means only are given for the small fish. Fish from Aquarium indicated in solid circles.

of predators in the form of sharks. In the later winter and early spring, sharks are not numerous in Boca Grande and Captiva Passes and probably cut no figure in the matter of any consequence. In the late spring and summer they become exceedingly numerous and voracious. In fact, in the summer it may become almost impossible to land a tarpon, once hooked, because as soon as one gives evidence of being in difficulty, shown by its peculiar swimming movements, the sharks close in, leaving the angler half a fish or only the head. This fact gives some indication of the size and capabilities of these sharks, some of which are easily able to bite through a six- or seven-foot tarpon at one stroke. This condition forced Mr. Bishop to abandon angling in August of both 1938 and 1939 for purposes of tagging. The fish generally become more numerous during that month and many could be hooked, but it was almost impossible to bring any to the boat intact. Consequently it is inferred that early in the year the shark factor is practically negligible but later nearly completely neutralizes any useful effect that the release of hooked tarpon might have, for during the quarter or half hour period that the tarpon take to recover they would evidently be easy prey to any marauding shark, including those that might not have the courage to strike a hooked tarpon not very distant from a boat.

Although no distinct migratory movement is apparent from these returns, an examination of Text-figure 9 indicates that more were taken to the north of the place of release than to the south, actually 10 to the north and 2 to the south. Expressed in terms of northern distance in miles from the place of release, the captures stand as indicated in Table XVI. It is also evident from these calculations that the group as a whole showed little drift to the west—actually 9 to the west and 3 to the east. The averages of the distances north and west traveled, considering south and east as negative, show that there was a mean drift of 2.39 miles to the north and a mean drift of 0.29 miles to the west. These fish were all tagged in July or August when local belief has it that the fish are moving north along the coast.

The State of Louisiana, Mathes (1940) reported, started efforts to tag tarpon in that area. Monel strap tags were experimentally affixed to the dorsal fin. This method was earlier tried by us but not put into practice for two reasons. One was the rather discouraging experiences in the past with other species and the other that since much of the tarpon fishing in the Charollette Harbor region is done at night and only the head of the fish brought out of water before releasing, it was felt that a more anterior position for the tags was desirable. There have evidently been no results reported so far from the Louisiana venture.

In connection with the fate of the tags used by us, it was found that the strap tags used either on jaw, operculum, tail, dorsal fin or fleshy part of the back were generally unsatisfactory, tending to set up local irritations, become loose and be shortly cast. The button tags secured to the operculum, two celluloid discs fastened by a pin of pure block tin, did not have such objections if placed well in from the edge. If close to the edge they would frequently tear out. Those that were retained by small land-locked fish would remain for the periods noted, and the external disc frequently became the focus of long, streaming, algae growths, which, however, did not seem to bother the fish in any way. Specimens held in the thoroughly controllable laboratory pool on Palmetto Key, after losing their tags, very quickly healed the perforation so that after a month or so no mark showing the former location of the tag could be found. It is not clear just in what manner the tags were lost. The tin pins seemed perfectly intact on all those recovered. If some corrosive action of environment and physiology is not involved, it is conceivable that the action involved might be entirely mechanical, as the periods of time would give ample opportunity for the exterior disc to become slightly loosened and catch on aquatic growths. The tags were placed firmly against the operculum but there was in no case any evidence of an overgrowth of tissues, the tags remaining completely free at all times.

Discussion.

The accumulated data on the absence of larval and postlarval tarpon from shore waters indicate that they presumably spend this part of their life history off-shore either in deep or surface waters. In order to determine this, elaborate tow-netting operations from an ocean-going craft would seem in order. Such a project was planned but the restrictions due to the war time conditions made prosecution impossible. It is hoped to undertake this program as soon as conditions make such activity possible.

The tentative scale analysis indicates that the markings on tarpon probably do indicate numbers of winters passed and that those small specimens taken in land-locked pools are stunted and not part of the perpetuating population. Other estimates of age based on similar specimens have been given by Breder (1933), who found from 2 to 4 checks on land-locked specimens on Andros Island, Bahamas. Coker (1921a) reported no checks on a fish 25 cm. long from open waters in Alabama, and Gill (1907) thought fish of 5.7 to 8.5 cm. in Puerto Rico to be "probably young of the first year." These cases are in keeping with our present findings. Babcock (1936) after much study gives what he calls "little more than a guess" as to the size of tarpon at various ages. Translated to metric measures his values stand as follows:

Length in cm.	Years
30.5— 35.6	1
50.8— 63.5	2
127.0—152.5	3

The growth indicated for the first and second year is in close agreement with our present data as indicated in Text-figures 3 and 7. Since Babcock's "total length" is probably equivalent to our "length including jaw," the agreement is even closer than is at first apparent. The third year is, however, much higher than our indications would call for. The lower estimate is within the present range of extremes but the upper falls without. It would seem that the growth between the second and third year is much too great in Babcock's calculations, for it is more than three times as large as that which he indicates between the first and second. This is obviously a most unlikely condition in practically any growing animal. In another place he indicates that he believes that tarpon of 142.0 cm. may be in their ninth or tenth year, which again agrees closely with our data as indicated in the same Text-figures. This suggests that his figures for the third year are in the nature of some inadvertency of typography.

In all these calculations of the possible age of tarpon, based on scale analysis, it seems to be taken for granted that they form a check the first winter in life. On this we obviously have no data. It has been shown that very small fish do form a check under land-locked conditions but we have no data as to the length of time that is spent as a leptocephalus. It may be a very brief period or a very extended one, covering even a year or more. The discussion here

TABLE XV. TARPON TAGGED, BY LOCALITIES AND DATES.
Fish were released at site of capture unless otherwise noted.

DATE	NO. OF FISH	TYPE OF TAG	SERIAL NUMBERS OF TAGS	FISH RELEASED AT
			FISH TAKEN IN PONDS AND DITCHES	
			PINE ISLAND	
			One to two miles north of St. James City. (Ditch).	
7/ 6/38	32	Disc	15004 to 15035.	San Carlos Bay.
7/11/38	7	Disc	15036 to 15039, 15070, 15071, 15073.	—
2/26/39	4	Disc	13420 to 13423.	—
3/ 7/39	3	Disc	13411 to 13413.	—
			SANIBEL ISLAND	
			One-half mile south of Wulfert. (Pond).	
8/ 9/38	2	Strap	10338, 10339.	—
			One-half mile south-west of Point Ybel. (Ditch).	
8/ 2/38	1	Strap	10202.	—
8/ 4/38	47	Strap	10258 to 10267, 10269 to 10284, 10286 to 10288, 10290 to 10291, 10293 to 10308.	—
8/ 9/38	37	Strap	10340 to 10342, 10344 to 10347, 10349 to 10351, 10353 to 10354, 10356 to 10357, 10359 to 10376, 10378 to 10380, 10382 to 10383.	—
8/25/38	20	Disc	15190 to 15195, 15212 to 15221, 15231 to 15234.	—
	25	Disc	15196 to 15211, 15222 to 15230.	South shore of Sanibel.
3/30/39	5	Disc	13424 to 13428.	Laboratory pond, Palmetto.
			Three and one-quarter miles south-west of Point Ybel. (Pond).	
7/20/38	10	Disc	15078, 15080 to 15084, 15086, 15090, 15093, 15094.	—
	26	Disc	15095 to 15120.	South shore of Sanibel.
8/ 2/38	54	Strap	10203, 10205 to 10257.	South shore of Sanibel.
	1	Strap	10250.	—
8/ 4/38	7	Strap	10309, 10311, 10312, 10314, 10315, 10335 to 10336.	—
	17	Strap	10316 to 10332.	South shore of Sanibel.
8/23/38	46	Disc	15121 to 15166.	—
8/24/38	22	Disc	15167 to 15184, 15186 to 15189.	South shore of Sanibel.
1/30/39	10	Disc	13400 to 13405, 13407 to 13410.	—
			GASPARILLA ISLAND	
			Two miles north of Boca Grande. (Railroad ditch).	
6/28/38	1	Disc	15000.	—
6/30/38	2	Disc	15001, 15002.	—
7/ 4/38	1	Disc	15003.	Charlotte harbor.
			CAPTIVA ISLAND	
			Near Redfish Pass. (Pond).	
8/18/38	1	Strap	10384.	—
			FISH TAKEN IN PASSES AND OUTSIDE WATERS	
			BOCA GRANDE PASS	
7/ 6/38	3	Disc	15050 to 15052.	—
7/ 7/38	2	Disc	15053, 15054.	—
7/ 9/38	1	Disc	15055.	—
3/23/39	2	Strap	10448, 10450.	—
3/24/39	6	Strap	10401, 10431, 10436, 10440, 10411, 10406.	—
3/28/39	1	Strap	10415.	—
4/ 4/39	1	Strap	10460.	—
4/ 9/39	2	Strap	10408, 10414.	—
4/16/39	1	Strap	10509.	—
4/20/39	1	Strap	10510.	—
4/21/39	2	Strap	10513, 10413.	—
4/22/39	1	Strap	10438.	—
4/25/39	1	Strap	10512.	—
4/26/39	1	Strap	10439.	—
4/28/39	2	Strap	10404, 10405.	—
4/30/39	3	Strap	10519 to 10521.	—
5/ 1/39	2	Strap	10534, 10535.	—
5/ 2/39	1	Strap	10533.	—
5/ 3/39	1	Strap	10488.	—
5/ 4/39	1	Strap	10532.	—

TABLE XV (CONTINUED)—TARPON TAGGED, BY LOCALITIES AND DATES.

DATE	NO. OF FISH	TYPE OF TAG	SERIAL NUMBERS OF TAGS	FISH RELEASED AT
5/ 5/39	2	Strap	10487, 10489.	—
5/ 6/39	2	Strap	10522, 10523.	—
5/13/39	1	Strap	10402.	—
5/14/39	1	Strap	10403.	—
5/18/39	1	Strap	10486.	—
5/20/39	1	Strap	10491.	—
5/22/39	2	Disc	13415, 13416.	—
5/23/39	2	Strap	10466, 10469.	—
5/25/39	1	Strap	10490.	—
5/28/39	1	Strap	10449.	—
6/ 2/39	1	Strap	10476.	—
6/ 3/39	2	Strap	10477, 10531.	—
6/ 5/39	1	Strap	10480.	—
7/28/39	1	Strap	10723.	—
8/ 7/39	2	Strap	10712, 10713.	—
8/11/39	1	Strap	10716.	—
6/18/41	1	Disc	46926.	—
7/ 3/41	3	Disc	46927 to 46929.	Palmetto Key.[1]
			CAPTIVA PASS	
7/12/38	1	Disc	15074.	—
7/13/38	2	Disc	15075, 15076.	—
7/14/38	1	Disc	15077.	—
3/26/39	3	Strap	10409, 10441, 10443.	—
4/ 9/39	1	Strap	10506.	—
5/ 1/39	2	Strap	10478, 10479.	—
8/ 6/39	2	Strap	10706, 10707.	—
8/ 9/39	1	Strap	10714.	—
8/10/39	1	Strap	10715 .	—
			REDFISH PASS	
5/15/39	1	Strap	10451.	—
			PALMETTO KEY	
			Off west shore.	
7/10/39	1	Strap	10701.	—

[1] These fish were collected by Mr. M. B. Bishop late in May, and with others were held at the laboratory until this date of release. They constituted some of the material discussed by Breder (1942e).

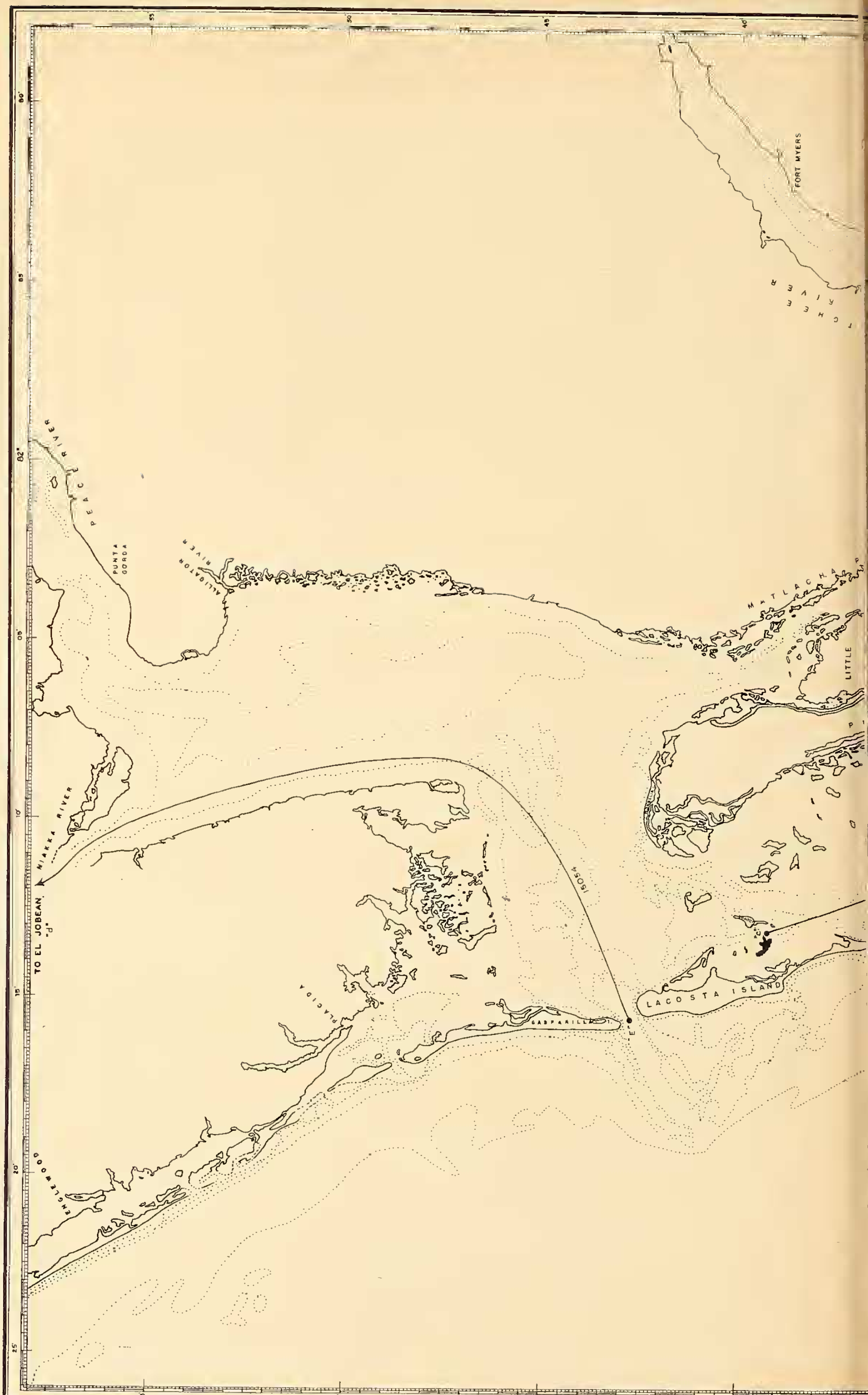
as to age is made with this in mind, pending the discovery of the leptocephalus stage and an understanding of its duration.

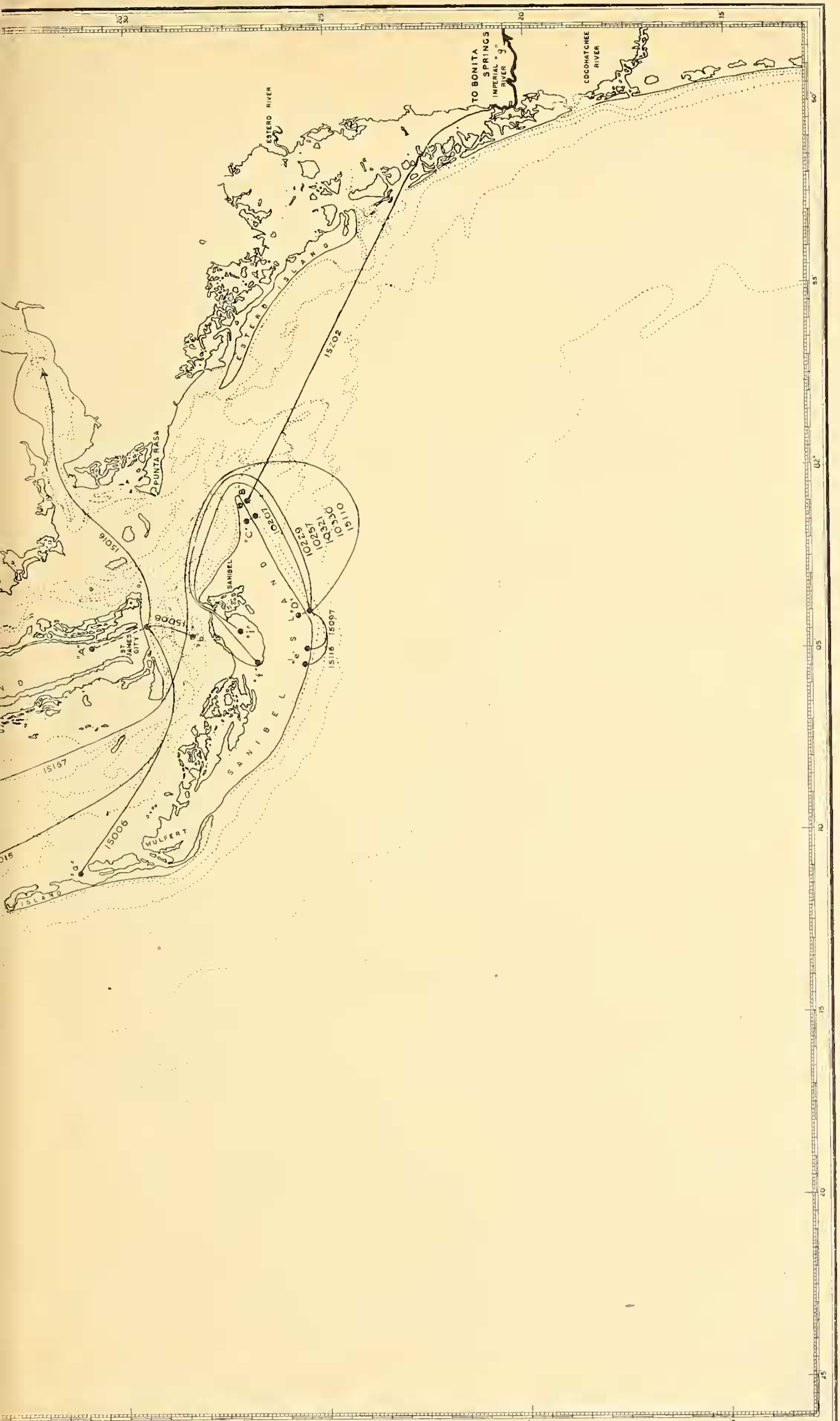
Babcock (1936) gives extended data on the seasons when "angler's" tarpon appear at various places on the Gulf coast. This could be interpreted as a northward migration with the coming of spring, or in various other fashions. The populations may be fairly static without any marked migratory behavior, simply keeping out of sight and not taking anglers' offerings if the water be sufficiently cold. Throughout their range it seems that there are some present at all times and it has been shown that the respiratory rises are less in cold water, as would be expected. This could easily give the impression in the field of comparative absence.

On the other hand, the data on tagging give a suggestion that there may be a slight northward drift of the fishes, but these data are too few to be taken very seriously. This is another matter that cannot be resumed until world conditions become more nearly normal, for tagging at this time could not be expected to produce any reasonable number of returns with so few people angling.

The assembled data indicate that tarpon may not reach sexual maturity until after passing their sixth or seventh winter. This may be a little too old, for there is still considerable uncertainty about the development of adventitious rings or perhaps spawning checks. In this connection it should be mentioned that in the larger fishes of about this size upward, there were in most cases vague ill-defined bands between the fairly sharp "winter" checks. These were evidently different in nature and placed about half way between the latter. They were not counted in these studies, but it is suspected that they may be spawning marks, which tends to support the general views here expressed. Since tarpon spawn at the warmest time of year and feed actively nearly or quite up to the time of spawning and are ravenous immediately thereafter, it may well account for the diffuse nature of these bands that have been tentatively considered as possible "spawning" checks.

Although tarpon are found on the west coast of Africa, Fowler (1936) and International Game Fish Association (1943),


FORT MYERS
PEACE RIVER
PUNTA GORDA
ALLIGATOR RIVER
MATLACHA
LITTLE
MYAKKA RIVER
TO EL JOBEAN "J"
15054
PLACIDA
GASPARILLA
LACOSTA ISLAND
ENGLEWOOD



TEXT-FIG. 9. Chart of region showing deployment of tagged specimens. Based on data of Table XVI. Serial tag numbers, capital letters, at place of release, small letters at place of recovery refer to that table. The connecting lines indicate the short water route. Palmetto Key is indicated in black.

TEXT-FIG. 9. Chart of region showing deployment of tagged specimens. Based on data of Table XVI. Serial tag numbers, capital letters, at place of release, small letters at place of recovery refer to that table. The connecting lines indicate the short water route. Palmetto Key is indicated in black.

TABLE XVI. RECOVERY OF TARPON, WITH DETAILED DATA ON EACH FISH.
Measurements in cm. total length.

Tag no.	Tag date	Site of[1] release	Length	Recovery date	Place of[1] recovery	Captor's data	Elapsed[2] days	Statute miles covered: Distance	Statute miles covered: Short route	Miles from point of release[3]: North	Miles from point of release[3]: West
15006	7/ 6/38	"A"	33.5	10/10/38	"a"	4½ lbs.	96	7.5	9.0	1.48	5.62
15008	7/ 6/38	"A"	27.5	9/ ?/38	"b"	About 15″	*56*	2.0	2.0	−1.35	0.66
15015	7/ 6/38	"A"	34.0	11/ 1/38	"c"	5 lbs.	118	12.0	17.0	8.35	6.88
15016	7/ 6/38	"A"	38.0	9/19/38	"j"	—	*75*	7.5	9.0	2.35	−5.62
15054	7/ 6/38	"E"	1193.8	9/17/38	"d"	About 3½′	72	19.0	25.0	14.50	−2.66
15097	7/20/38	"D"	39.0	3/ 5/41	"e"	No fish	228	?	?	—	—
15110	7/20/38	"D"	36.0	10/ ?/38	"f"	—	*88*	2.5	12.0	1.09	1.09
15116	7/20/38	"D"	38.5	4/ 5/39	"e"	No fish	254	?	?	—	—
10207	8/ 2/38	"D"	38.0	3/ ?/42	"i"	—	*1326*–?[4]	2.5	10.5	—	—
10229	8/ 2/38	"D"	35.5	10/ ?/38	"f"	—	*75*	2.5	12.0	1.09	1.09
10257	8/ 2/38	"D"	33.5	10/ ?/38	"f"	—	*75*	2.5	12.0	1.09	1.09
10321	8/ 4/38	"D"	37.5	10/ ?/38	"f"	—	*73*	2.5	12.0	1.09	1.09
10330	8/ 4/38	"D"	33.0	10/ ?/38	"f"	—	*73*	2.5	12.0	1.09	1.09
15167	8/24/38	"D"	36.0	9/24/38	"h"	1½′	31	11.0	18.0	3.50	3.18
15202	8/25/38	"E"	49.0	10/ ?/38	"g"	5½ lbs.	*63*	16.5	19.0	−5.57	−10.01
										Mean 2.39	0.29

[1] Letters under "Site of release" and "Place of recovery" refer to the localities indicated in Text-figure 9.
[2] Italicised dates of recovery and days elapsed refer to date of letter sent by captor where accurate dates were not obtainable.
[3] South and east expressed as the negative of north and west respectively.
[4] Presumably this fish was caught much earlier than date of letter. Further information unobtainable.

TABLE XVII. SUMMARY OF ALL TARPON TAGGED.

Location of Original Capture

NUMBER OF FISH	LOCALITY
	Land-locked
46	Pine Island (1 ditch)
352	Sanibel Island (2 ditches, 2 ponds)
4	Gasparilla Island (1 ditch)
1	Captiva Island (1 pond)
403	All ponds and ditches
	Open waters
61	Boca Grande Pass
14	Captiva Pass
1	Redfish Pass
1	Off Palmetto Key
77	All open waters
480	All fish tagged

PLACES OF RELEASE

Small fish released where tagged, in presumably land-locked pools and ditches	226
Small fish released in open waters	177
Large fish in open waters	77
Total	480
Total available for retaking in open waters	254
Total available only in ponds and ditches	226

CLASSIFICATION OF RECOVERIES

Numbers retaken in open waters	13[1]
Percentage recovered	5+
Numbers retaken in ponds, etc.	8
Percentage recovered	4—
Numbers of large fish retaken	1
Percentage recovered	1+
Numbers of small fish retaken	12
Percentage recovered	7—

[1]Omitting 2 tags cast and subsequently found on beach.

and are general throughout the West Indian islands, the coasts of northern South America, Central America and the Gulf of Mexico and do occur in less numbers on the east coast of Florida, they do not occur north of there except as stragglers. At Bermuda they are uncommon, Beebe and Tee-Van (1933). This type of distribution is not uncommon. Whether the Bermuda fish are to be considered as larvae caught in the eastward edge of the Gulf Stream, which have grown up in Bermuda waters, or whether they are accidental strays of larger fish like those that occur irregularly all along the Atlantic coast as far north as Massachusetts, is uncertain, but the indications would seem to be that the larvae are kept, or are able to stay, largely within the Gulf circulation and that it is mainly the larger specimens that have moved outward to form these accidental strays.

SUMMARY.

1. The development of an egg and larva believed to be that of the tarpon is described, down to the pre-leptocephalus stage.
2. Dimensional changes with age and size are discussed and found to be remarkably small, from young to adult specimens.
3. The fate of small land-locked specimens is discussed and the conclusion reached that they are in the nature of peripheral wastage and do not partake in the support of the adult population.
4. The area of successful spawning is considered to be in the blue non-estuarine waters, because of the great abundance of predaceous plankton in the inside green waters.